INSTRUCTION MANUAL
NUMBER B-4365

EG&G

MODEL 580 RADIOMETER
MODEL 580/585 SPECTRORADIOMETER
MODEL 585 SPECTRORADIOMETER

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COPY /

ELECTRO-OPTICS DIVISION
EG&G, INC., 35 CONGRESS ST., SALEM, MASSACHUSETTS 01970

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ADDENDUM 1

MODEL 580-00-13 UV NARROW BEAM ADAPTER

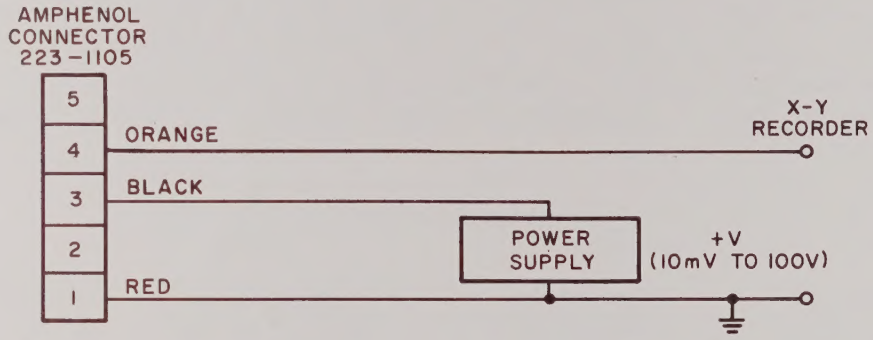
The Model 580-00-13 UV Narrow Beam Adapter is an accessory that is similar to the Model 580-00-11 Narrow Beam Adapter. It is designed for making measurements of narrow beams of light or coherent laser beams with diameters less than 5/8 inch. The Model 580-00-13 UV Narrow Beam Adapter utilizes quartz optics to permit measurements from 250 to 1100 nm. It can be used with the Model 580-20A Series Detector Heads and the Model 585-60 Series High-Sensitivity Detector Heads. A typical calibration data sheet for this accessory is shown.

Narrow Beam Adapter Calibration
580-00-13 S/N 270

Wavelength Nanometers	Sensitivity W/SQ-CM/W	Wavelength Nanometers	Sensitivity W/SQ-CM/W
250	4.61E-04	700	1.19E-03
260	4.64E-04	750	1.28E-03
270	4.90E-04	800	1.39E-03
280	5.25E-04	850	1.46E-03
290	5.63E-04	900	1.50E-03
300	5.88E-04	950	1.55E-03
310	6.19E-04	1000	1.60E-03
320	6.30E-04	1050	1.71E-03
330	6.61E-04	1100	1.75E-03
340	6.93E-04	1150	1.78E-03
350	7.16E-04		
375	7.33E-04		
400	8.07E-04		
450	9.05E-04	488.0	9.36E-04
500	9.72E-04	514.5	9.77E-04
550	1.02E-03	632.8	1.13E-03
600	1.13E-03	694.3	1.17E-03
650	1.15E-03	1060	1.73E-03

Certificate No. 580-00-13-270-1
Calibrated By Date

Each Digital Grating is fitted with a 10-turn potentiometer which is connected to the grating wavelength drive mechanism. This feature permits electric output (linear with wavelength) to an appropriate X-Y recorder. A three-lead cable is supplied with each unit for connection to the potentiometer. The following schematic should be used:



The external supply voltage, +V, should not exceed (+) 100 volts. This system produces an output voltage (up to the maximum supply voltage) that increases linearly with wavelength. This voltage can be used to either manually drive or automatically drive (with Model 585-11-13 Spectrum Scanner) the X-coordinate of an X-Y recorder.

The voltage output from the recorder output (REC OUT) terminal on the Model 580-10 Series Indicator Units is used to drive the Y-coordinate so that a direct plot of intensity versus wavelength can be obtained.

ADDENDUM 2

MODEL 585-20D SERIES DIGITAL GRATINGS

Note: The Model 585-20D Series of Digital Gratings replaces the Model 585-20 Series of Gratings described in the manual. The Model 585-11-11 Wavelength Transducer is no longer required, and has been obsoleted.

Model 585-20D Series Digital Gratings are used with the Model 585-11 Monochromator Housing in all Spectroradiometer configurations. The gratings, when inserted, form the top of the Monochromator Housing. (Four captive screws on the grating top secure the grating assembly to the Monochromator Housing.) The gratings have a four-digit wavelength dial with readout direct to 1 nm.

The Model 585-22D Grating is a 1350-groove-per-millimeter grating covering the visible region from 350 to 800 nanometers in the first order. It is blazed at 500 nm. The reciprocal linear dispersion is 6.4 nanometers per millimeter.

The Model 585-23D Grating is a 675-groove-per-millimeter grating covering the infrared region from 700 to 1600 nanometers in the first order. It is blazed at 1 micrometer. The reciprocal linear dispersion is 12.8 nanometers per millimeter.

The Model 585-24D Grating is a 2700-groove-per-millimeter grating covering the ultraviolet region from 180 to 400 nanometers in the first order. It is blazed at 250 nanometers. The reciprocal linear dispersion is 3.2 nanometers per millimeter.

The Model 585-25D Grating is a 337.5-groove-per-millimeter grating covering the infrared region from 1.4 to 3.2 micrometers in the first order. It is blazed at 2.0 micrometers. The reciprocal linear dispersion is 25.0 nanometers per millimeter.

The wavelength accuracy of each grating is as follows:

Model 585-22D	± 2 nm
Model 585-23D	± 5 nm
Model 585-24D	± 1 nm
Model 585-25D	± 5 nm

ADDENDUM 3

MODEL 585-11-13 SPECTRUM SCANNER

The Model 585-11-13 Spectrum Scanner can be used in all spectroradiometer systems utilizing the Model 585-20D Series Digital Gratings for those applications which require wavelength scanning. The scan speed for the various gratings is as follows:

Model 585-24D	UV Grating	100 nm/minute
Model 585-22D	VIS Grating	200 nm/minute
Model 585-23D	IR No. 1 Grating	400 nm/minute
Model 585-25D	IR No. 2 Grating	800 nm/minute

The Spectrum Scanner mounts onto the side of the Digital Gratings. To mount the Spectrum Scanner, remove the manual drive knob from the Grating and locate the Spectrum Scanner in position using the two mounting holes and the drive shaft. Attach the manual drive knob to the Spectrum Scanner drive shaft. The Spectrum Scanner operates from a 110-volt, 60-Hz line (220-volt, 50-Hz model is available).

ADDENDUM 4

MODEL 585 IR RADIOMETER

The Model 585 IR Radiometer consists of a Model 585-55 IR Detector Head, a Model 585-42 Chopper, and a Model 580-34 Filter Holder. The spectral range of the instrument is 0.7 to 3.2 μm. A typical spectral response curve is shown.

The system components bayonet together in the following order. The Model 580-34 Filter Holder mounts between the Model 585-55 Detector Head and the Model 585-42 Chopper. The Model 585-42 Chopper bayonets onto the Model 580-34 Filter Holder with its motor on the source side of the system.

The reference surface for all measurements is the PbS Detector, which is located 8.25 cm from the front surface of the clear anodized diffuser retainer located just in front of the dewar window.

585 Radiometer Calibration

Model No.	Description	S/N
585-55	Detector Head	105
585-42	Chopper	620

Certificate No. 585-55-105-1D
Calibrated by D. Moody Date 6-27-72

EG&G certifies that the calibration presented herein was performed using standards traceable to the National Bureau of Standards.

Wavelength Micrometers	Sensitivity A/W/CM^2	Wavelength Micrometers	Sensitivity A/W/CM^2
1.0	5.04×10^{-3}	2.2	8.40×10^{-3}
1.1	5.54×10^{-3}	2.3	8.33×10^{-3}
1.2	6.05×10^{-3}	2.4	8.30×10^{-3}
1.3	6.79×10^{-3}	2.5	8.20×10^{-3}
1.4	7.12×10^{-3}	2.6	8.23×10^{-3}
1.5	7.49×10^{-3}	2.7	7.40×10^{-3}
1.6	7.59×10^{-3}	2.8	6.38×10^{-3}
1.7	7.76×10^{-3}	2.9	2.78×10^{-3}
1.8	7.93×10^{-3}	3.0	1.50×10^{-3}
1.9	8.23×10^{-3}	3.1	7.56×10^{-4}
2.0	8.33×10^{-3}	3.2	4.06×10^{-4}
2.1	8.40×10^{-3}		

ADDENDUM 5

MODEL 580-34 FILTER HOLDER

The Model 580-34 Filter Holder can be used to mount any of the order-sorting filters supplied with the Model 580/585 and 585 Spectroradiometer Systems, or any special narrow-bandpass filters used in Model 580 and 585 Radiometer System applications. Two filters, if required, can be inserted into one holder. Round filters not exceeding 2. 75 inches (70 mm) in diameter, and square filters not exceeding 2. 0 inches (51 mm) in side dimension can be mounted without modification. Spring clips, permanently fastened to the slide-in filter holder, position and retain the filters. Bayonet-type coupling enables the unit to be quickly attached to other system components.

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SECTION 1

INTRODUCTION

1.1 GENERAL

EG&G makes available a variety of systems to measure or characterize the spectral output of pulsed or steady-state light sources over a wide spectral range. These are the

Model 580 Radiometer System (Figure 1)

Model 580/585 Spectroradiometer System using a Model 580-20A Series Detector Head (Figure 2)

Model 580/585 Spectroradiometer System using a Model 585-60 Series Detector Head (Figures 3 and 4)

Model 585 Spectroradiometer System using a Model 580-26 or a Model 585-55 Detector Head (Figure 5)

Three Model 580-10 Series Indicator Units are available for reading the signal output of the above systems. These are the

Model 580-11A Indicator Unit (Figure 10)

Model 580-12 Digital Indicator Unit (Figure 11)

Model 580-15 Synchronous Amplifier Unit (Figure 12).

The Models 580-11A and 580-12 Indicator Units can be used with all of the above mentioned Detector Heads with the exception of the Model 585-55 Detector Head. The Model 580-15 Synchronous Amplifier can be used with all of the above mentioned Detector Heads in a Spectroradiometer System.

The major components of the various configurations are discussed separately (see Section 2). Table 1 lists the major components and indicates which are associated with each system.

NOTE

Keep in mind that many components are common to more than one system.

1.2 MODEL 580 RADIOMETER SYSTEM

The EG&G Model 580 Radiometer System (Figure 1) is a compact, portable, and versatile assemblage of precision instruments designed for the quantitative measurements of steady-state or pulsed light. With meter and recorder readout, it is capable of making the direct measurement of average power of continuous light sources or the total integrated energy of pulsed-light sources. Provision has been made to use an oscilloscope for output measurements of peak power and waveform of pulsed events.

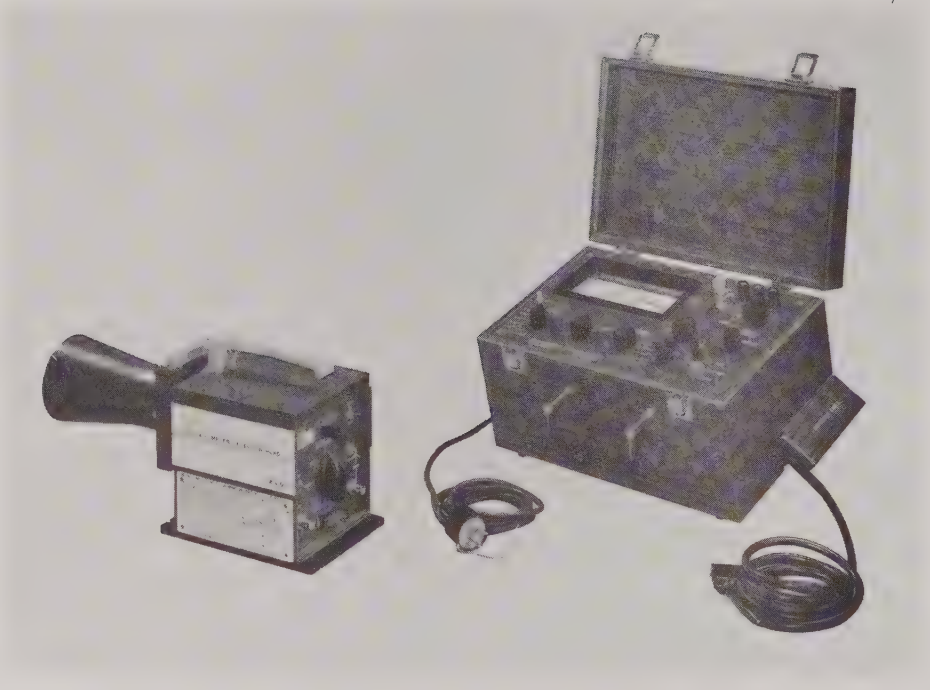


Figure 1. Basic Model 580 Radiometer System.

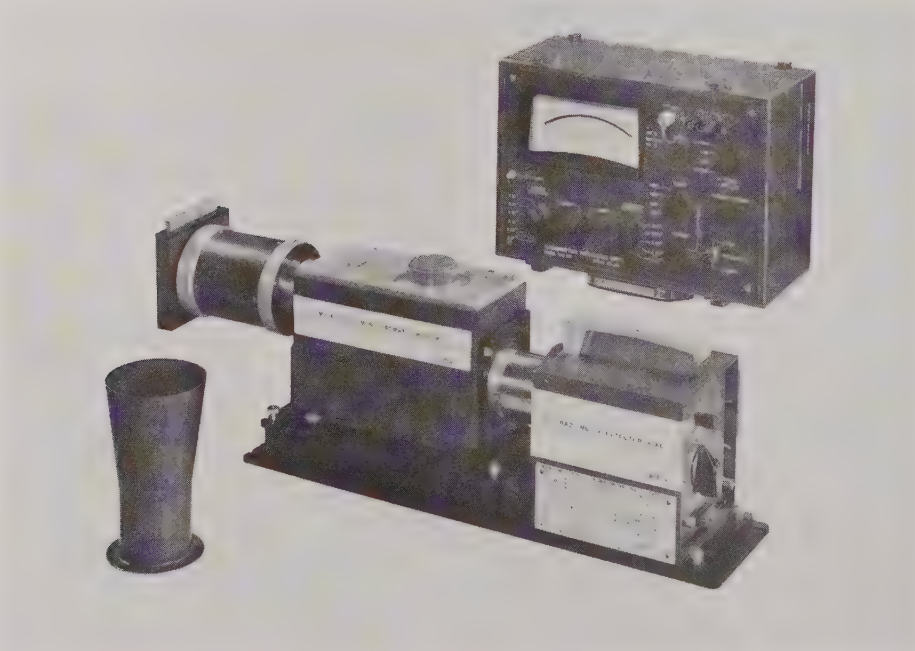


Figure 2. Basic Model 580/585 Spectroradiometer System.

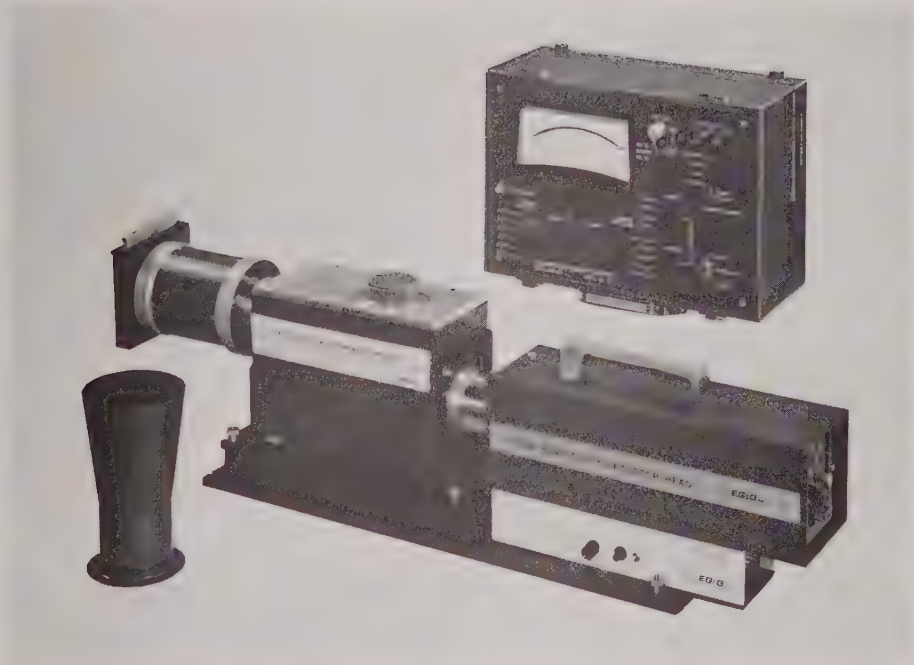


Figure 3. Model 580/585 Spectroradiometer System Using a Model 585-62, 585-64, or 585-66 High Sensitivity Detector Head.

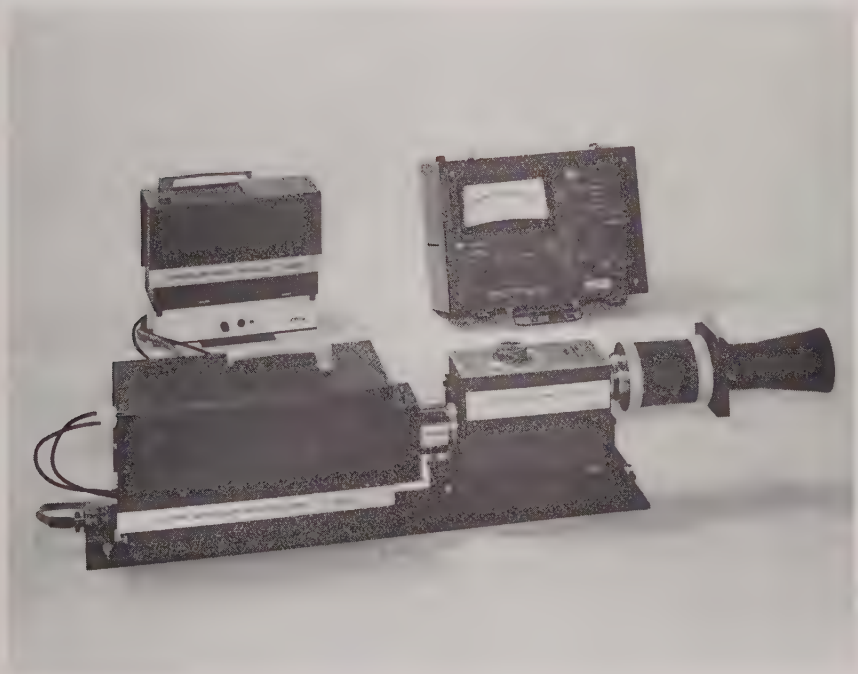


Figure 4. Model 580/585 Spectroradiometer System Using a Model 585-63 High-Sensitivity Detector Head.

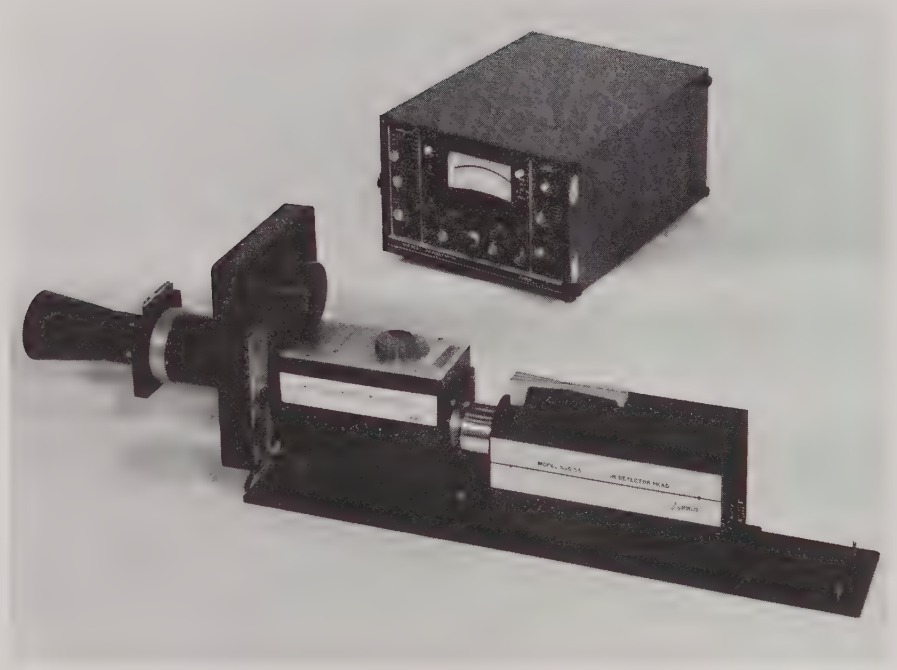


Figure 5. Model 585 Spectroradiometer System Using a Model 585-55 IR Detector Head.

The basic Model 580 Radiometer System consists of the following components (see also Table 1):

Model 580-11A or 580-12 Indicator Unit

Model 580-20A Series Detector Head

Model 580-32 Hooded Filter Holder.

The following accessories may be purchased for use with the Model 580 Radiometer System:

Model 580-00-30 Series Photometric Filter (used with the Model 580-22A or 580-25A Detector Head)

Model 580-00-11 Narrow-Beam Adapter/Laser Attenuator

Model 580-00-12 Laser-Beam Sampler

Model 580-33 Series Narrow Field of View Adapter

Model 585-36 Telescope

Model 585-00-15 Tripod.

The versatility of the Model 580 Radiometer System has led to a variety of applications in areas of light-source evaluation and laser measurements. The system covers the complete spectral range from 200 nanometers in the ultraviolet region to 1150 nanometers in the near infrared.

Table 2 lists the model number, surface sensitivity, and spectral range of response of the three Model 580-20A Series Detector Heads available.

Table 1. Radiometer and Spectroradiometer System Configurations.

	Model 580 Radiometer			Model 580/585 Spectroradiometer					Model 580/585 Spectroradiometer High Sensitivity							Model 585 Spectroradiometer			
	580-22A	580-23A	580-25A	580-22A	580-23A	580-23A	580-25A	580-25A	585-62	585-62	585-63	585-63	585-64	585-66	585-66	580-26	580-26	585-55	585-55
	S20	S1	S5	S20	S1	S1	S5	S5	S20	S20	S1	S1	Solar Blind	S10	S10	Silicon	Silicon	PbS	PbS
	350-800	350-1150	200-750	350-800	350-800	700-1150	200-400	350-750	200-400	350-800	350-800	700-1150	200-400	200-400	350-800	400-800	700-1100	700-1600	1400-3200
Model 580-11A Indicator Unit	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*		
Model 580-12 Indicator Unit	0	0	0	0	0	0	0		0	0	0	0	*	0	0	*			
Model 580-15 Synchronous Amplifier				0	0	0	0	*	0	0	*	0	*	0	0	*	*	*	*
Model 580-22A Detector Head	*			*															
Model 580-23A Detector Head	*	*			*	*													
Model 580-25A Detector Head			*				*	*											
Model 585-62 Detector Head									*	*									
Model 585-63 Detector Head											*	*							
Model 585-64 Detector Head													*						
Model 585-66 Detector Head														*	*				
Model 580-26 Detector Head																*	*		
Model 585-55 Detector Head																		*	*
Model 585-00-60 Power Supply									*	*	*	*	*	*	*				
Model 585-00-63 Controller											*	*							
Model 580-32 Hooded Filter Holder	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Model 585-11 Monochromator Housing				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Model 585-22 Grating				*	*			*		*	*			*		*			
Model 585-23 Grating						*						*					*	*	
Model 585-24 Grating							*		*				*	*					
Model 585-25 Grating																			*
Model 585-20-21 Fixed Slits (3.00 mm Exit)				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Model 585-20-22 Fixed Slits (1.5 mm Exit)				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Model 585-20-23 Fixed Slits (0.75 mm Exit)				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Model 585-20-24 Variable Slits				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Model 585-32 Beam Input Optics				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Model 585-42 Chopper				0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*
Model 585-20-12 Filter				*	*			*		*	*				*	*			
Model 585-20-13 Filter				*	*	*		*		*	*	*			*	*	*	*	
Model 585-20-14 Filter						*						*					*	*	
Model 585-20-16 Filter				*	*			*		*	*				*	*			
Model 585-20-17 Filter				*	*		*	*	*	*	*		*	*	*	*			
Model 585-20-18 Filter																			*
Model 585-20-19 Filter																			*
Model 585-00-11 Adapter				*	*	*	*	*	*	*			*	*	*	*	*		
Model 585-00-12 Adapter				0	0	0	0	0	0	0	*	*	0	0	0	0	0	*	*
Model 585-00-13 Adapter				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table 1. (Continued)

	Model 580 Radiometer			Model 580/585 Spectroradiometer					Model 580/585 Spectroradiometer High Sensitivity							Model 585 Spectroradiometer			
	580-22A	580-23A	580-25A	580-22A	580-23A	580-23A	580-25A	580-25A	585-62	585-62	585-63	585-63	585-64	585-66	585-66	580-26	580-26	585-55	585-55
	S20	S1	S5	S20	S1	S1	S5	S5	S20	S20	S1	S1	Solar Blind	S10	S10	Silicon	Silicon	PbS	PbS
	350-800	350-1150	200-750	350-800	350-800	700-1150	200-400	350-750	200-400	350-800	350-800	700-1150	200-400	200-400	350-800	400-800	700-1100	700-1600	1400-3200
Model 580-00-31 Photometric Filter			0																
Model 580-00-32 Photometric Filter																			
Model 580-00-33 Photometric Filter	0			0						0									
Model 580-00-11 Narrow Beam Adapter	0	0	0	0	0	0		0		0	0	0			0		0		
Model 580-00-12 Laser Beam Sampler	0	0	0	0	0	0		0		0	0	0					0		
Model 585-00-15 Tripod	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Model 585-11-11 Wavelength Transducer				0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Model 585-11-12 Drive Knob Set, Wavelength Transducer				0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Model 580-33-5 5° Adapter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Model 580-33-10 10° Adapter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Model 585-35-11 End-on Viewing Head										0	0	0			0				
Model 585-35-12 Side Viewing Head										0	0	0			0				
Model 585-35-13 Fiber Optics Probe										0	0	0			0				
Model 585-35-14 Probe Input Optics										0	0	0							
Model 585-36 Telescope	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Model 585-36-11 Radiometer Telescope Aaapter	0	0	0		0		0												
Model 585-38-11 Microscope										0	0	0			0				
Model 585-38-12 X-Y Positioning Slide										0	0	0			0				
Model 585-38-13 Post Mounting Bracket										0	0	0			0				
Model 585-38-02 Objective 2X											0	0							
Model 585-38-100 Objective 10X											0	0			0				
Model 585-38-21 Objective 21X										0	0	0			0				
Model 585-38-43 Objective 43X										0	0	0			0				
Model 585-38-60 Objective 60X										0	0	0			0				
Model 585-38-15 Objective Telescope										0	0	0			0				

Table 2. Model 580-20A Series Detector Head Spectral Ranges.

	Model 580-22A	Model 580-23A	Model 580-25A
Surface	S20	S1	S5
Spectral Range (nm)	350-800	350-1150	200-750

The Model 580 System is designed for measurement of both cw light sources and pulsed-light sources having risetimes as fast as 1 nanosecond. It has a linear dynamic-response range of over 12 decades. The absolute accuracy is ±8% in the visible and IR regions and ±15% in the UV. Precision is better than 1%. The average NBS uncertainty is approximately 3% in the visible and IR and 8% in the UV.

The Model 580-20A Series Detector Head houses a photodiode, an aperture system, and a diffuser disc. Provision is made for tripod mounting, detector alignment, and output terminals for oscilloscope display of pulsed-light waveform signals. Figure 6 is a functional block diagram of a radiometer.

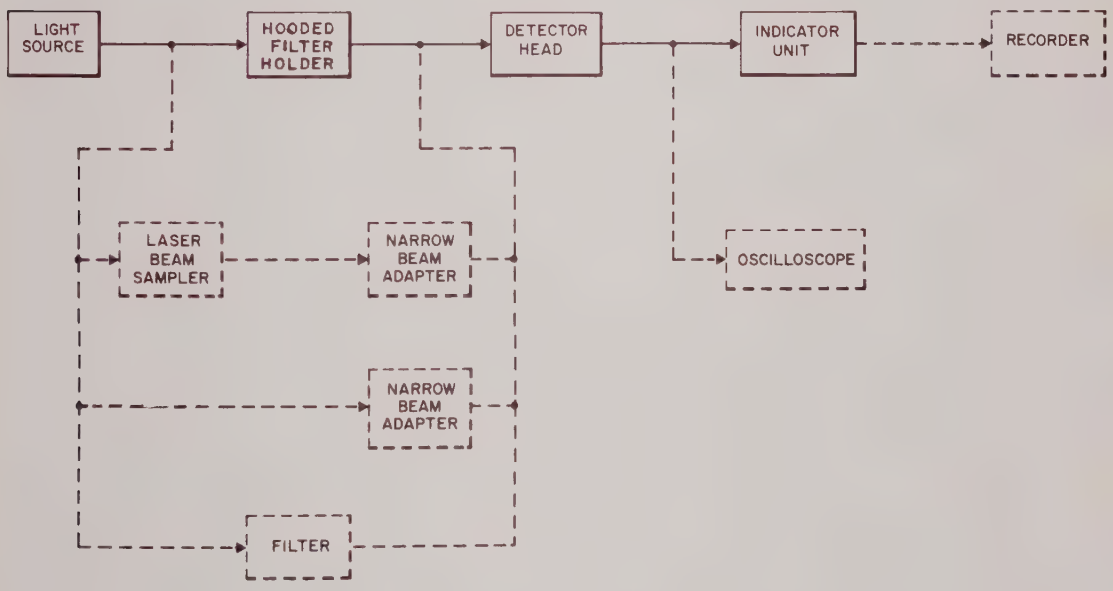


Figure 6. Functional Block Diagram of a Radiometer.

1.3 MODEL 580/585 SPECTRORADIOMETER SYSTEM

The Model 580/585 Spectroradiometer System (Figure 2) facilitates measurement of light sources of unknown spectral output without resorting to a series of expensive filters. This system allows the user to make the absolute measurements of average power, time-integrated power (energy), peak power, and pulse shape at any desired wavelength having a discrete known bandwidth.

The basic Model 580/585 Spectroradiometer System consists of the following components:

- Model 580-11A or 580-12 Indicator Unit
- Model 580-20A Series Detector Head
- Model 585-32 Beam Input Optics
- Model 585-11 Monochromator Housing
- Model 585-20 Series Gratings
- Model 585-20-20 Series Fixed Slits
- Model 585-00-11 Adapter (or 585-00-12 Adapter)
- Model 585-20-10 Series Filters
- Model 580-32 Hooded Filter Holder

The following accessories may be purchased for use with the Model 580/585 Spectroradiometer System (see also Table 1):

- Model 585-20-24 Variable Slits
- Model 585-11-11 Wavelength Transducer
- Model 580-33 Series Narrow Field of View Adapter
- Model 585-36 Telescope
- Model 585-00-15 Tripod

The Model 580/585 System can also be used with the Model 580-15 Synchronous Amplifier being substituted for the Model 580-11A or the Model 580-12 Indicator Unit. If such a substitution is made, the Model 585-42 Chopper would also be required. Except in the case of the chopped system, the Model 580/585 Spectroradiometer has the facility for oscilloscope display of peak-power and waveshape measurements at any desired wavelength having a finite bandwidth. The Model 580-20A Series Detector Head is easily demountable and can readily be used as a basic radiometer system after the proper diffusers have been installed in the detector head. (See subsections 1.2 and 2.5.1.)

Figure 7 is a functional block diagram of a spectroradiometer, and Figure 8 is a graphic representation of minimum-maximum sensitivity levels using various detector heads.

1.4 SPECTRORADIOMETER WITH MODEL 585-60 SERIES HIGH-SENSITIVITY DETECTOR HEADS

The Model 585-60 Series High-Sensitivity Detector Heads are used with the Model 580/585 Spectroradiometer to enable absolute measurements of low intensity, pulsed or cw, light levels (see Figures 3 and 4). These Detector Heads incorporate photomultiplier tubes to provide approximately

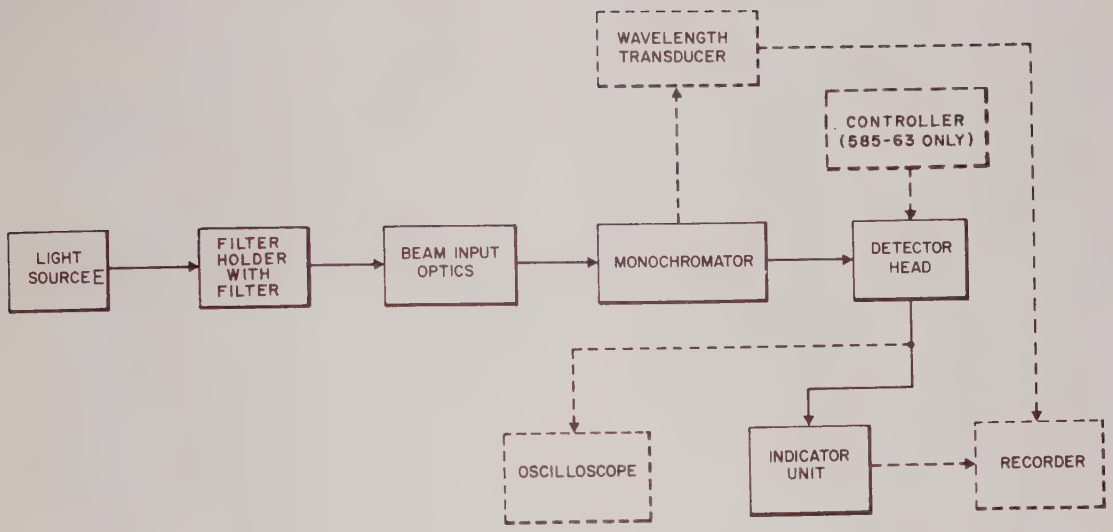


Figure 7. Functional Block Diagram of a Spectroradiometer.

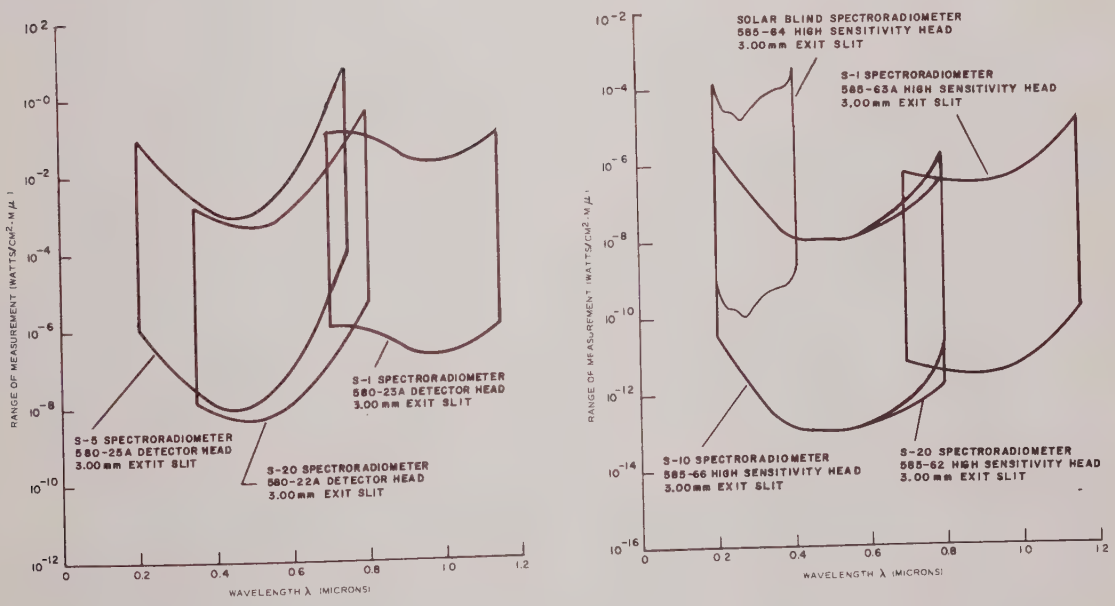


Figure 8. Minimum-Maximum Sensitivity Levels of Model 580/585 Spectroradiometer System.

five decades of additional sensitivity over that furnished by the Model 580-20A Series Detector Heads. The four Detector Heads available are listed in Table 3, along with the spectral range encompassed by each head.

The basic Model 580/585 Spectroradiometer System utilizing the Model 585-60 Series Detector Heads consists of the following components (see also Table 1):

Model 580-11A or 580-12 Indicator Unit

Model 585-60 Series Detector Heads

Model 585-00-60 Power Supply

Model 585-32 Beam Input Optics

Model 585-11 Monochromator Housing

Model 585-20 Series Gratings

Model 585-20-20 Series Fixed Slits

Model 585-00-11 Adapter (585-00-12 Adapter is required for 585-63 Detector Head)

Model 585-20-10 Series Filters

Model 580-32 Hooded Filter Holder

The Model 580/585 can also be used with the Model 580-15 Synchronous Amplifier replacing the Model 580-11A or Model 580-12 Indicator Unit. If such a replacement is made, the Model 585-42 chopper would also be required.

The following additional component is required for the Model 580/585 Spectroradiometer System utilizing the Model 585-63 Detector Head (see also Table 1):

Model 585-00-63 Controller

The following accessories may be purchased for use with the Model 585-60 Series version of the Spectroradiometer System:

Model 585-20-24 Variable Slits

Model 585-11-11 Wavelength Transducer

Model 585-35 Series Fiber Optics Probe (except 585-64)

Model 585-36 Telescope

Model 585-38 Series Microscope (except 585-64)

Model 585-00-15 Tripod

Model 580-33 Series Narrow Field of View Adapter

The High Sensitivity Detector Heads can also be used as a radiometer or a photometer. In this configuration, either opal glass (visible and IR) or ground-quartz (UV and visible) is threaded into the front of the detector, and the monochromator housing is omitted.

The following accessories may be purchased for use when the Model 585-60 Series Detector Heads are utilized as radiometers.

Table 3. Model 585-60 Series High-Sensitivity Detector Heads Spectral Ranges.

	Model 585-62	Model 585-63	Model 585-64	Model 585-66
Photo Surface	S20	S1	Solar Blind	S10
Spectral Range (nm)	200-800	350-1150	200-400	200-800

Model 580-00-11 Narrow Beam Adapter/Laser Attenuator (except 585-64)

Model 580-00-12 Laser Beam Sampler (except 585-64)

Model 580-00-32 Photometric Filter (585-66 only)

Model 580-00-33 Photometric Filter (585-62 only)

585-35 Series Fiber Optics Probe (except 585-64)

585-36 Telescope

585-38 Microscope (except 585-64)

Model 580-33 Series Narrow Field of View Adapter

Model 585-00-15 Tripod

Energy and average power measurements with the high-sensitivity configurations are obtained directly from the multi-decade meter of the Model 580-11A or Model 580-12 Indicator Unit or from an external recorder.

Provision is also made for output to an oscilloscope for pulsed sources. Applications with the high-sensitivity configurations include measurements of phosphors, chemical reaction, electroluminescence emissivity and reflectivity of surfaces, biochemical analysis, and other low-level signals.

Any system configuration using the 580-15 Synchronous Amplifier will make average power measurements only. The readings can be displayed on the multi-decade, scale expandable meter or on an external recorder.

1.5 MODEL 585 SPECTRORADIOMETER WITH MODEL 585-26 OR 585-55 DETECTOR HEAD

The Model 580-26 Silicon Detector Head uses a silicon detector and covers the spectral region from 400 to 1100 nanometers. The Model 585-55 IR Detector Head (Figure 5) uses a lead sulfide detector and covers the spectral region from 700 to 3200 nanometers. Typical response curves of these two systems are shown in Figure 9.

The system uses synchronized detection to enhance the stabilized signal-to-noise performance of a Detector Head. The electrical signal input to the Model 580-15 Synchronous Amplifier is amplified and applied to a pair of full-wave demodulator switches which are synchronized to the frequency and phase of a reference signal generated in the Model 585-42 Chopper. The demodulator output, after low-pass filtering, is a d-c level proportional to the average value of the input signal. The d-c level is indicated on a panel meter and is correlated to the actual Detector Head signal current by a decade gain switch and a three-position meter scale expander switch.

The basic Model 585 Spectroradiometer System consists of the following components:

Model 580-15 Synchronous Amplifier

Model 585-42 Chopper

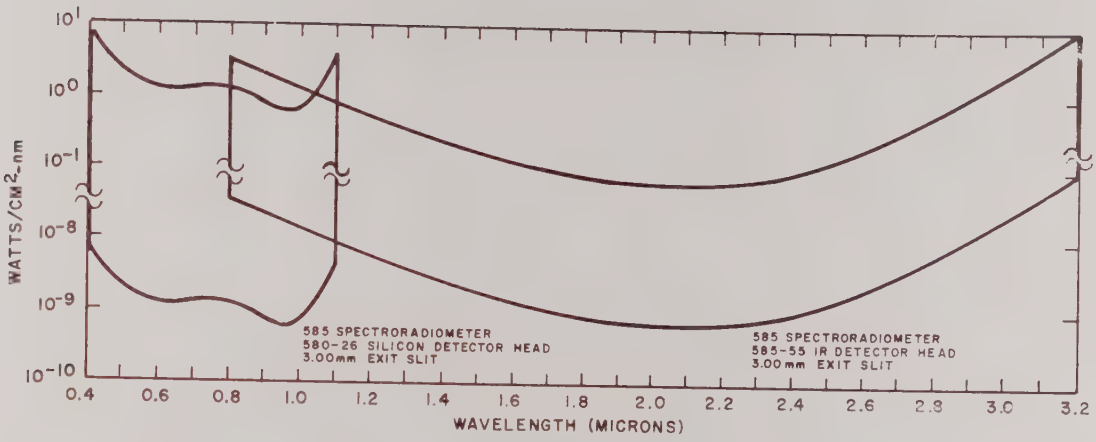


Figure 9. Minimum-Maximum Sensitivity Levels of Model 585 Spectroradiometer.

Model 585-55 or 580-26 Detector Head

Model 585-32 Beam Input Optics

Model 585-20 Series Gratings

Model 585-11 Monochromator Housing

Model 585-20-20 Series Fixed Slits

Model 585-00-10 Series Adapter

Model 585-20-10 Series Filters

Model 580-32 Hooded Filter Holder

Although essentially designed for use with the Models 585-55 and 580-26 Detector Heads, the 580-20A Series and the 585-60 Series Detector Heads can also be used with the Model 580-15 Synchronous Amplifier and the Model 585-42 Chopper.

The following accessories may be purchased for use with the Model 585 Spectroradiometer:

Model 585-20-24 Variable Slits

Model 585-11-11 Wavelength Transducer

Model 585-36 Telescope

Model 585-33 Series Narrow Field of View Adapters

Model 585-00-15 Tripod

The 580-26 Detector Head can also be used with the Model 580-11A or 580-12 Indicator Units, in which case the Model 585-42 Chopper would not be required. The Model 580-26 Detector Head, in this case, could be used in a spectroradiometer system or as a radiometer.

SECTION 2

DESCRIPTION OF COMPONENTS

2.1 GENERAL

This section contains a description of each component of the four basic systems and an explanation of their principal operational features. Illustrations of each component are provided. The major components (physical) are discussed first, followed by the peripheral items (adapters, filters, holder, and viewing hood).

2.2 MODEL 580-11A INDICATOR UNIT (Model 580 Radiometer and Model 580/585 Spectroradiometer Systems)

2.2.1 General

The Model 580-11A Indicator Unit (Figure 10) can be used with all radiometer and spectroradiometer systems with the exception of those using a Model 585-55 IR Detector Head. It serves three purposes: charge-current indication, system control panel, and power supply. The Detector Head interconnecting cable and power cable are stored for easy access through spring-lock ports in the side of the case. At the option of the operator, the Indicator Unit can be energized from external power or from the internal battery. A two-minute warm-up time stabilizes all circuits.

Figure 10. Model 580-11A Indicator Unit.

2.2.2 Characteristics

Charge Scales: 10×10^{-11} to 10×10^{-7} coulomb (five individual switch positions)

Current Scales: 10×10^{-11} to 10×10^{-6} ampere (six individual switch positions)

Ambient Compensation: Low, medium, high, with vernier (compensates for net effect of ambient light level and detector leakage). Maximum compensation current available is more than 4 μA.

Pulse Minimums for Energy Measurement (Meter): 1.0 nanosecond pulse width minimum.

Power Requirements: 117V, 80 mA, 50 to 60 Hz or 230V, 50 to 60 Hz as specified by the customer (operator's choice of external power or internal rechargeable battery operation).

Battery Operating Time: 6 to 8 hours (depending on amount of ambient compensation needed).

Battery Recharge Time: 8 hours.

Battery Life: 1 year (minimum).

Dimensions: 13 inches long by 8 inches wide by 10 inches deep.

Weight: 15 pounds.

2.2.3 Controls and Readout

The function of each control is explained as follows:

(1) POWER switch: The four-position switch selects method of energizing system. Operation from an external a-c source or an internal battery is at user's option.

a. OFF position: All power to System shut off. POWER ON indicator lamp not lit.

b. LINE position: External line voltage applied; System energized. POWER ON lamp blinks; meter illuminated. Internal battery charges.

c. BATTERY position: Internal battery voltage applied; System energized. POWER ON lamp blinks; meter not illuminated.

d. CHARGE position: External line voltage charges battery. POWER ON lamp blinks; meter scale illuminated.

(2) BATTERY indicators: The two indicators show the condition of the internal rechargeable battery.

a. CHG indicator: Color changes from red at full-charge condition to colorless at no charge.

b. DIS indicator: Color changes from red at no-charge condition to colorless at full charge.

NOTE

Rate of battery drain depends on ambient light conditions encountered. Limited experience will permit reasonable operator judgments of remaining time for battery operation and/or remaining time to acquire full battery charge.

(3) "Function" switch: The two-position switch selects steady-light measuring circuit (current) or pulsed-light measuring circuit (charge).

a. CURRENT position: Used for steady-light-source measurements. Connects current-measuring circuits to meter for measurement of average signal power.

b. CHARGE position: Used for pulsed-light-source measurements. Connects charge-measuring circuits to meter for measurement of integrated signal energy.

(4) AMPERE MULTIPLIER switch: Six-position switch to select proper meter scale when "function" switch is in CURRENT position.

(5) COULOMB MULTIPLIER switch: Five-position switch to select proper meter scale when "function" switch is in CHARGE position.

(6) INTEGRATE switch: Three-position switch controls measurement of a pulsed-light event. It can be used with three synchronizing terminals (labeled SYNC) on the front panel to initiate a pulsed-light event. A single-pole, double-throw switch (S7), operated mechanically by the INTEGRATE switch, acts as a synchronizing trigger. In the RESET position, the N. O. terminal is disengaged from the SYNC connector, which is engaged with the N. C. terminal. When the INTEGRATE switch is placed in INTEGRATE position, the SYNC terminal shorts to the N. O. terminal and the N. C. terminal is opened. This trigger technique minimizes any uncompensated error due to preflash integration of ambient light in pulsed-light measurements. It also eliminates the uncertainty of manual synchronization of measurement in pulsed-light events, except for those of random nature which cannot be triggered.

NOTE

A smooth manual push action from the RESET position through the INTEGRATE position to the HOLD position is the proper operating technique for this switch when measuring pulsed light.

a. RESET position: Discharges integrating circuits and returns meter needle to zero in preparation for measurement of a flash event. Position is normal one for all current measurements.

b. INTEGRATE position: Places integrating circuits in "ready" status for time-integrated light measurements. Same as RESET for current measurements.

c. HOLD position: Disconnects detector circuit after meter displays final reading of pulsed-light event to permit accurate observation. Meter drift rate in HOLD is less than 0. 1% full scale in 15 seconds. Position also used for setting meter zero in CURRENT position for all measurements.

(7) ZERO SET potentiometer: Located on POWER switch. Establishes electrical zero on meter prior to light measurements.

(8) COMPENSATION controls: Nullify effects of normal steady ambient light and also compensate detector dark current or leakage so that source measurements are essentially direct reading, even in sunlight.

a. RANGE switch: Selects compensation range needed to nullify effects of normal ambient light.

Since three current scales (low, medium, and high) overlap, correct setting is quickly determined.

b. VERNIER potentiometer: Fine adjustment for zeroing meter indication. Operates in conjunction with the RANGE switch.

(9) "Measurement Indicator Meter:" Microammeter with 0.5% tracking accuracy. Construction incorporates a taut band suspension which eliminates hysteresis and binding problems. The top scale on the meter face is marked from 0 to 10 and the bottom scale on the meter face is marked from 0 to 3. These major scale divisions are further divided into tenths by easily read scale markings. Meter is direct reading in amperes or coulombs as determined by position of "function" switch and associated scale setting.

(10) X3 MULTIPLIER control: Expands meter scale indication and REC OUT voltage to allow using 0-to-3 instead of 0-to-10 scale.

(11) REC OUT connector: The recorder output is a voltage of 10 mV for full-scale meter deflection. Impedance of this output is 200 ohms. The REC OUT signal can be used with the Wavelength Transducer to give an X-Y plot of signal intensity.

(12) CURRENT DAMPING control: An averaging device to dampen out small noise fluctuations of signal (from an unsteady source of variations in ambient light). Also gives average value of a train of pulses in current mode. Can be used for steadying out noise fluctuations with High-Sensitivity Heads at extremely low levels. Works on all current scales except $\times 10^{-6}$. The RC time constant for current dampening is variable from 5 milliseconds to 5 seconds; however, the meter response time is typically only 0.5 seconds.

2.3 MODEL 580-12 DIGITAL INDICATOR UNIT (Model 580 Radiometer and Model 580/585 Spectroradiometer Systems)

2.3.1 General

The Model 580-12 Digital Indicator Unit (Figure 11) can be used with all Radiometer and Spectroradiometer Systems with the exception of those using the Model 585-55 IR Detector Head. It serves three purposes: charge-current indication, system control panel, and power supply. The Detector Head interconnecting cable and power cable are stored for easy access through spring-lock ports in the side of the case. A two-minute warm-up time stabilizes all circuits. The Model 580-12 Digital Indicator Unit is similar to the Model 580-11A Indicator Unit. The

Figure 11. Model 580-12 Digital Indicator Unit.

major difference is that the Model 580-12 has a four-digit Nixie display and binary coded decimal T^2L parallel outputs.

2.3.2 Characteristics

Charge Scales: 10×10^{-11} to 10×10^{-7} coulomb (five individual switch positions)

Current Scales: 10×10^{-11} to 10×10^{-6} ampere (six individual switch positions)

Ambient Compensation: Low, medium, high, with vernier (compensates for net effect of ambient light level and detector leakage). Maximum compensation current available is more than 4 μA.

Pulse Minimums for Energy Measurement: 1.0 ns pulse width minimum.

Digital Display: 4-digit Nixie with most significant digit 1 or 0.

Maximum Reliable Indication: 16.00

Data Conversion Rate: 2 conversions/second.

Decimal Point: Fixed.

Accuracy: 0.05% ± one count.

Analog Display: A vertical analog meter is mounted beside the digital display to provide an analog presentation of the digital information. It is useful for initial set-up of a measurement where rapidly changing signal levels cannot be followed on the digital display.

Digital Output: 3-BCD 8-4-2-1 digits plus one bit most significant digit.

Polarity: + polarity indicated by upper logic level.

Range Digits: 1-BCD 8-4-2-1 digit plus one bit most significant digit.

Maximum Conversion Rate: 60 conversions/second (external trigger).

Conversion Speed: 9.9 ms.

Conversion Mode: Independent of previous measurement.

Conversion Complete Signal: Upper to lower level transition.

Clock Output: 300 kHz.

Upper Logic Level Signal: 3.5 ± 0.1V sourcing 0.1 mA.

Lower Logic Level Signal: 0.2 ± 0.2V sinking 5 mA.

Command Read-Data Available Delay: 9.9 ms.

Digital Control Inputs: External trigger, internal sample rate control Hold and Read.

External Trigger: 1 μs minimum pulse width.

Upper Logic Level Load: 10 μA.

Lower Logic Level Load: 1.6 mA.

BCD Output Pin Connections:

FUNCTION	PIN NO.	FUNCTION	PIN NO.
Overload Output	1	Digit 3	
Conversion Complete	2	Bit 1	14
Clock Output	3	Bit 2	15
Digital Ground	4 & 31	Bit 4	16
Internal Sample Rate or Hold and Read	5	Bit 8	17
		Digit 4	
External Trigger	6	Bit 1	30
Polarity	32	Range Digit 1	
Digit 1		Bit 1	19
Bit 1	10	Bit 2	20
Bit 2	11	Bit 4	21
Bit 4	12	Bit 8	22
Bit 8	13	Range Digit 2	
Digit 2		Bit 1	23
Bit 1	26		
Bit 2	27		
Bit 4	28		
Bit 8	29		

NOTES:

1. Digit No. 1 and Range Digit No. 1 are the least significant digits.
2. BCD Output connector is Amphinol Microribbon Miniature Connector part number 57-10360 with mating connector, Amphenol part number 57-40360.

Power Requirements: 117V, 115mA, 50 to 60 Hz or 230V, 50 to 60 Hz as specified by the customer.

Dimensions: 13 inches long by 8 inches wide by 10 inches deep.

Weight: 16 pounds.

2.3.3 Controls and Readout

The function of each control is explained as follows:

(1) POWER switch: The two-position switch energizes the system from the a-c power source.

a. OFF position: All power to the System shut off.

b. LINE position: External line voltage applied; System energized. Nixie digits illuminated.

(2) "Function" switch: The two-position switch selects steady-light measuring circuit (current) or pulsed-light measuring circuit (charge).

a. CURRENT position: Used for steady-light-source measurements. Connects current-measuring circuits to meter for measurement of average signal power.

b. CHARGE position: Used for pulsed-light-source measurements. Connects charge-measuring circuits to meter for measurement of integrated signal energy.

(3) AMPERE MULTIPLIER switch: Six-position switch to select proper meter scale when "function" switch is in CURRENT position.

(4) COULOMB MULTIPLIER switch: Five-position switch to select proper meter scale when "function" switch is in CHARGE position.

(5) INTEGRATE switch: Three-position switch controls measurement of a pulsed-light event. It can be used with three synchronizing terminals (labeled SYNC) on the front panel to initiate a pulsed-light event. A single-pole, double-throw switch (S7), operated mechanically by the INTEGRATE switch, acts as a synchronizing trigger. In the RESET position, the N.O. terminal is

disengaged from the SYNC connector, which is engaged with the N. C. terminal. When the INTEGRATE switch is placed in INTEGRATE position, the SYNC terminal shorts to the N. O. terminal and the N. C. terminal is opened. This trigger technique minimizes any uncompensated error due to preflash integration of ambient light in pulsed-light measurements. It also eliminates the uncertainty of manual synchronization of measurement in pulsed-light events, except for those of random nature, which cannot be triggered.

NOTE

A smooth manual push action from the RESET position through the INTEGRATE position to the HOLD position is the proper operating technique for this switch when measuring pulsed light.

a. RESET position: Discharges integrating circuits and returns meter to zero in preparation for measurement of a flash event. Position is normal one for all current measurements.

b. INTEGRATE position: Places integrating circuits in "ready" status for time-integrated light measurements.

c. HOLD position: Disconnects detector circuit after meter displays final reading of pulsed-light event to permit accurate observation. Meter drift rate in HOLD is less than 0. 1% full scale in 15 seconds. Position is also used for setting meter zero in CURRENT position for all measurements.

(6) ZERO SET potentiometer: Located on POWER switch. Establishes electrical zero on meter prior to light measurements.

(7) COMPENSATION controls: Nullify effects of normal steady ambient light and also compensate detector dark current or leakage so that source measurements are essentially direct reading, even in sunlight.

a. RANGE switch: Selects compensation range needed to nullify effects of normal ambient light. Since three current scales (low, medium, and high) overlap, correct setting is quickly determined.

b. VERNIER potentiometer: Fine adjustment for zeroing meter indication. Operates in conjunction with RANGE switch.

(8) REC OUT connector: The recorder output is a voltage of 0-5V for

full-scale meter deflection. The maximum load impedance that this signal can drive is 2.5 K ohms. The REC OUT signal can be used with the Wavelength Transducer to give an X-Y plot of signal intensity versus wavelength.

(9) CURRENT DAMPING control: An averaging device to dampen-out small noise fluctuations with High-Sensitivity Heads at extremely low levels. Works on all current scales except X 10^{-6}. The RC time constant for current dampening is variable from 5 milliseconds to 5 seconds.

2.4 MODEL 580-15 SYNCHRONOUS AMPLIFIER

2.4.1 General

The Model 580-15 Synchronous Amplifier (Figure 12) is used with all Model 580/585 or 585 Spectroradiometer Systems utilizing synchronized detection. It serves three purposes: current indication, system control panel, and power supply. The Chopper interconnecting cable and power cable are stored for easy access through a magnetic-lock door in the side of the case. A 5-minute warm-up time stabilizes all circuits.

2.4.2 Characteristics

Sensitivity Range: 10×10^{-13} to 10×10^{-3} amperes full scale (11 individual switch positions).

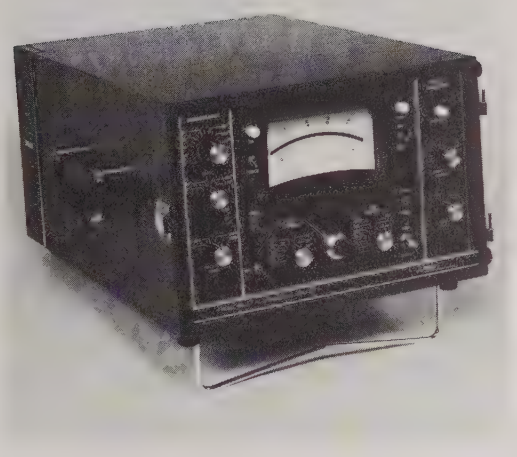


Figure 12. Model 580-15 Synchronous Amplifier.

Meter Scale Expansion: Full scale = 10, 5, 2 (three-position switch).

Frequency Range: 1-1000 Hz (three individual switch positions).

Time Constant: 1 millisecond to 30 seconds (11-position switch).

Phase Control: Coarse (0°, 90°, 180°, 270° steps) and Fine (0° to 180° continuous control.

Equivalent Noise Input: 4×10^{-13} peak to peak amperes/$Hz^{1/2}$.

Noise Effective Bandwidth: 0.008 Hz for 30-second response time.

Meter Accuracy: ±1% full scale; ±0.5% tracking.

Amplifier Overload: Illuminated panel light.

Meter Overload: Illuminated panel light.

Power Requirements: 50/60 Hz, 115V, 130 mA or 230V, 65 mA, as specified by the customer. A complete 585 System, Synchronous Amplifier, IR Detector Head, and Chopper draws 870 mA (Detector Head cooling) and 720 mA (Detector Head at $0^{\circ}C$).

Recorder Output: +10V, 4 mA full scale.

Dimensions: 8 inches high by 12 inches wide by 17-1/2 inches deep.

Weight: 28 pounds.

2.4.3 Controls and Readout

The function of each control is explained as follows:

(1) POWER switch: The two-position switch controls a-c power to the system.

a. Switch down - off position: All power to the system is off.

b. Switch up - on position: External a-c voltage is applied to the System; pilot light is ON.

(2) AMPERES SENSITIVITY switch: Eleven-position switch selects proper meter range.

a. OVERLOAD indicator light: When continuously on indicates that signal level or noise level is too great for sensitivity setting being used; hence, level must be reduced.

(3) METER SCALE switch: Three-position switch expands meter scale to obtain as large an up-scale deflection as possible.

(4) TIME CONSTANT switch: Eleven-position switch selects proper time constant for damping small noise fluctuations in the signal. The System has two low-pass filters in series. Hence the actual System time constant is three times larger than the individual time constants indicated by the Time Constant switch. The effective signal bandwidth may be found by using the following equation:

$$\Delta f = \frac{1}{4\,RC}$$

where

RC = 3 times the time constant setting of the TC switch.

(5) FILTER RESET switch: A spring-return switch which discharges the TIME CONSTANT capacitors.

(6) METER switch: Two-position switch controls signal displayed on the meter.

a. SIG position: Output signal from Spectroradiometer is displayed on the meter.

b. REF position: Produces an up-scale reading on the meter indicating that the applied reference signal is being acquired and properly processed. METER switch should be set in REF position by setting switch to reset and then releasing. The switch

will spring-return to the REF position.

(7) ZERO SUPPRESS controls: These controls consist of a three-position (+, OFF, and -) switch, an 11-position ranging switch, and a potentiometer.

a. (+, OFF, -)switch: Controls polarity of compensation signal. In the (+) position, a positive compensation signal is introduced into the System. In the (-) position, a negative compensation signal is introduced into the System. The zero suppress signal is fed into the input of the first amplifier for a true a-c zero suppress function.

b. Range switch: Selects the compensation range to nullify the effects of an ambient light signal.

c. Vernier potentiometer: Fine adjustment for zeroing meter indication.

(8) FREQUENCY RANGE Hz switch: Three-position switch selects proper frequency range. Frequency of Model 585-42 Chopper is 87 Hz.

(9) PHASE controls: Four-position step switch (0^{o}, 90^{o}, 180^{o}, and 270^{o}) and a continuous control 0-180^{o} switch normally adjusted to yield maximum output.

(10) PANEL LITE switch: Three-position switch. When the switch is in the down position, the panel light is ON low range; when in the up position, the panel light is ON high range; and when in the middle position, the panel light is OFF.

(11) RCDR OUTPUT connector: BNC output provides +10V full-scale signal into a 2.5-Kohm load. The output is proportional to the meter indication.

2.5 MODEL 580-20A SERIES DETECTOR HEADS (Models 580 Radiometer and 580/585 Spectroradiometer Systems)

2.5.1 General

All Model 580-20A Series Detector Heads (Figure 13) are basically the same. The difference in the designations (-21, -22, etc.) of the Detector Heads is based on the particular range of spectral response. This range is determined by the specific biplanar photodiode used in the Head (S1, S20, etc.). Each Head also has a diffuser disc, either opal glass (visible and infrared) or a pair of ground-quartz pieces (ultraviolet), a variable-aperture system with trimming potentiometers, and circuitry for input and output signals.

2.5.2 Optics

The Detector Head has a simple optics system in that incident light within a 14^{o} cone illuminates the diffuser. (Full illumination is necessary for calibrated

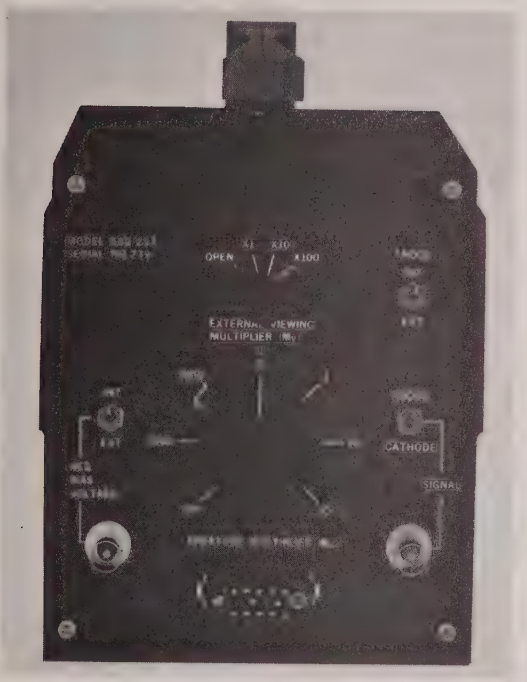


Figure 13. Model 580-20A Series Detector Head.

readings.) The opal diffusers have a relatively flat response for a $\pm 7^{o}$ field of view; whereas the ground quartz diffusers have a relatively flat response for a $\pm 2.5^{o}$ field of view. The Model 580-32 Hooded Filter Holder is constructed to eliminate any light outside this 14^{o} cone. The variable apertures simply select what portion of the diffuser the photodiode senses. Therefore, since the photodiode is always fully illuminated, there is no problem with surface linearity. There are eight steps of attenuation (or eight different aperture openings) in the aperture-disc system, with the 1-position looking at the whole diffuser and the 3000-position looking at a small portion of the diffuser. The apertures are made as accurately as possible in the ratios of 1 to 3000, but ratio errors of up to about 8% are still possible. To correct for this mechanical mismatch in the Detector Head, there are trimmer potentiometers which put an additional electrical signal into the current summing junction of the Model 580-11A or 580-12A Indicator Unit to correct aperture settings to within 1%. If the Indicator Unit is not used with the Detector Head, then the correction is not made in the 3 through 3000 positions. (The photodiode itself is energized from the Indicator Unit or from an external source and acts as a linear current generator with output dependent on the intensity of the incident light.)

2.5.3 Functional Controls

All controls of the Detector Heads are located on the rear panel for ease of operation and readability. Both detent switches have pointer-type knobs for absolute position indication. The following subsection explains in detail the function of each control (also see Figure 13):

(1) NEG BIAS VOLTAGE switch (S3): This two-position switch selects the method of biasing the photodiode.

   a. INT position: Biases photodiode with -150V power supply in the Indicator Unit.

b. EXT position: Allows biasing of photodiode (up to 1000V) with any suitable external d-c power supply through BNC type connector (J2).

(2) ANODE switch: Provides a means to monitor anode output current signal either with Indicator Unit or an external oscilloscope.

a. INT position: Photodiode current signal is measured with Indicator Unit.

b. EXT position: Output current signal is measured with external instruments – see NOTE, item (5) below.

(3) SIGNAL switch: Provides a means to monitor output current signals from either anode or cathode of the photodiode.

a. ANODE position: Output current signal is taken from anode of photodiode.

b. CATHODE position: Output signal is taken from signal developed across 100K ohms in the cathode circuit of the photodiode. This is for pulsed-light conditions only.

(4) EXTERNAL VIEWING MULTIPLIER (Mv) switch: Provides three steps of signal sensitivity for oscilloscope viewing of pulsed-light signals.

a. OPEN position: Used when direct connection to photodiode with external readout (no load resistor) is desired.

b. X1 position: Furnishes a direct signal to the oscilloscope (across 5K ohms to ground).

c. X 10 position: Attenuates output voltage to oscilloscope by 10 (500 ohms to ground).

d. X 100 position: Attenuates output voltage to oscilloscope by 100 (50 ohms to ground).

(5) APERTURE MULTIPLIER (Ma) switch: Provides eight steps of attenuation to the viewed light signal, extending dynamic range of instrument optically. Switch positions are marked according to attenuation factor (1, 3, 10, 30, 100, 300, 1000, and 3000). Built-in compensation maintains aperture ratio accuracy when the diffuser disc is fully illuminated by uniform source irradiance and meter readout is employed.

NOTE

Aperture multiplier positions are within 8% accuracy when using external positions of the Detector Head; i. e., scope readout. When a Model 580-11A or Model 580-12 Indicator Unit is used, accuracy is within 1%.

2.5.4 Modes of Operation

With the Model 580-20A Detector Head, it is possible to operate in several different modes ranging from simultaneous readings on an Indicator Unit and oscilloscope (or other monitoring device) to a simple Indicator Unit readout. The operating modes are as follows (see also Figure 14):

(1) ANODE INT ONLY: The Model 580-11A or Model 580-12 Indicator Unit is used to provide bias voltage and signal readout from the Detector Head by setting the Detector switches as follows (this is the simplist mode of operation):

a. NEG BIAS VOLTAGE: INT
b. ANODE: INT
c. SIGNAL: ANODE
d. APERTURE MULTIPLIER: 1-position (or operator's choice)

(2) ANODE EXT ONLY: In this mode of operation, the signal from a source (usually pulsed) can be viewed by an oscilloscope. External bias can be used to provide a larger voltage (1000V maximum). Switches are set as follows:

a. NEG BIAS VOLTAGE: EXT
b. ANODE: EXT
c. SIGNAL: ANODE
d. APERTURE MULTIPLIER: 1-position (or operator's choice)
e. EXTERNAL VIEWING MULTIPLIER: operator's choice.

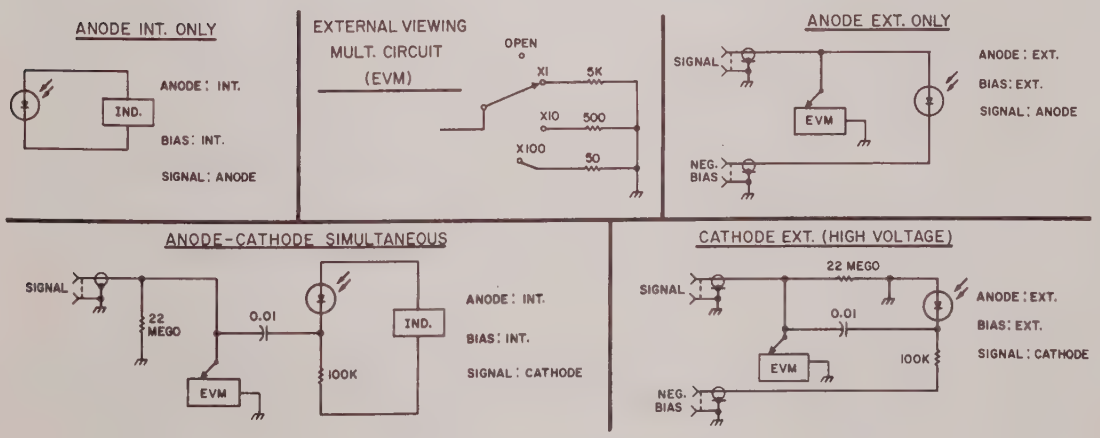


Figure 14. Model 580-20A Series Detector Head Operational Schematics.

The NEG BIAS VOLTAGE can also be set on INT to use the Indicator Unit supply. The EXTERNAL VIEWING MULTIPLIER is used as an attenuation device. This places 5K-(X 1), 500-(X 10), and 50-(X 100) ohm resistors in photodiode output circuit, with OPEN position having no resistor. Impedance matching is important in this mode.

NOTE

When a high-speed traveling-wave oscilloscope is used, the EXTERNAL VIEWING MULTIPLIER (Mv) switch should be in the OPEN position. If a very fast rising pulse is observed on the oscilloscope, capacity of connecting cable could affect signal.

(3) ANODE - CATHODE SIMULTANEOUS: Both an Indicator Unit and an oscilloscope can be used simultaneously to monitor output signal (pulse) of the Detector Head. The Detector bias is provided by the Indicator Unit. The switches are set as follows:

a. NEG BIAS VOLTAGE: INT
b. ANODE: INT
c. SIGNAL: CATHODE
d. APERTURE MULTIPLIER: 1-position (can be varied)
e. EXTERNAL VIEWING MULTIPLIER: operator's choice.

Again, the EXTERNAL VIEWING MULTIPLIER is an attenuation device for signal to oscilloscope (but not that to Indicator Unit). The APERTURE MULTIPLIER can be used for Indicator Unit signal (1%), but attenuation of external signal will only be within 8% accuracy.

NOTE

NEG BIAS VOLTAGE above 150V cannot be used when the Indicator Unit is used as a measuring device. This is when the ANODE switch is on INT.

(4) CATHODE EXT (HIGH VOLTAGE): This operation is somewhat similar to that described in (2) above, but has added benefit of isolating the oscilloscope from the high-voltage bias with a capacitor (0.01 μF). Switches are set as follows:

a. NEG BIAS VOLTAGE: EXT
b. ANODE: EXT
c. SIGNAL: CATHODE
d. APERTURE MULTIPLIER: 1-position
e. EXTERNAL VIEWING MULTIPLIER: operator's choice

The NEG BIAS VOLTAGE is still limited to 1000V maximum.

This operation is for pulsed sources only.

2.5.5 Visual-Alignment Aids

Permanent markings on the handle and on each side nameplate of the Detector Head are visual-alignment aids. The nameplate and handle centerlines coincide with the central axis of the Detector optical system. They are used as sighting aids in the vertical and horizontal planes. Additional diverging lines on the handle outline the 14^{o} field of view intercepted by the Model 580-32 Hooded Filter Holder. The position of the active detector surface (diffuser disc), from which light source-detector distances are measured is from the front surface of the Detector Head, or diffuser disc.

The following specifications pertain to all Model 580-20A Series Detector Heads (Table 4 gives the various spectral ranges as determined by the particular photodiode used):

Maximum Peak Current (amp): 150×10^{-3} with 150V internal bias; 1.0 with 1000V external bias.

Maximum Average Current: 10×10^{-6} amp.

Effective Active Area of Head: 2.58 square inches; 16.6 cm^2.

Viewing Resistors (ohms): Infinity (open), 50 (X 100), 500 (X 10), 5000 (X 1).

Pulse Risetime (Scope viewing): less than 1 ns with 1 kV (external) bias. Less than 4 ns with internal bias.

Aperture Ratios: 1, 1/3, 1/10, 1/30, 1/100, 1/300, 1/1000, and 1/3000.

Physical Characteristics:

Length: 6.5 inches (12.5 inches with 3.5-inch diameter hood)
Width: 5.25 inches
Height: 7 inches
Weight: 8 pounds

Table 4. Model 580-20A Series Detector Head Spectral Ranges

	Model 580-22A	Model 580-23A	Model 580-25A
Photo Surface	S20	S1	S5
Spectral Range (nm)	350-800	350-1150	200-750

2.6 MODEL 585-60 SERIES HIGH-SENSITIVITY DETECTOR HEADS (Model 580/585 Spectroradiometer)

2.6.1 General

The Model 585-62, 585-63, 585-64 and 585-66 High-Sensitivity Detector Heads (see Figures 15 and 16) comprise the Model 585-60 Series. These Detector Heads are designed essentially for use with the Model

Figure 15. Model 585-62, 585-64, or 585-66 High Sensitivity Detector Head (Model 585-00-60 Power Supply also shown to illustrate mounting).

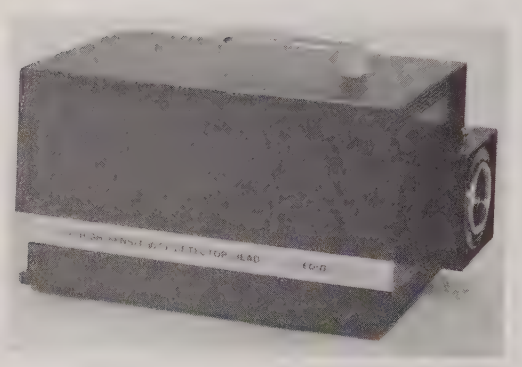


Figure 16. Model 585-63 High-Sensitivity Detector Head.

580/585 Spectroradiometer System, although all may also be calibrated as radiometers, if desired. They permit absolute measurements of low-intensity, pulsed or cw, light signals in the ultraviolet, visible, and infrared regions. (Refer to Table 3 for spectral range of each Detector Head.) Each incorporates a photomultiplier tube to provide approximately five decades of additional system sensitivity over that furnished by a Model 580-20A Series Detector Head (see subsection 1.4 and Figure 8 for additional data on Spectroradiometer System sensitivities).

All Detector Heads operate from the regulated power supplied by the Model 585-00-60 Power Supply, which is completely interchangeable between the two system configurations, although the manner of mounting and connections differs. The Model 585-63 Detector Head also operates in conjunction with the Model 585-00-63 Controller, which cools the PMT and assures a constant operating temperature. (Further details on these auxiliary components are presented in Section 3.)

2.6.2 Mechanical

Consistent with the Model 580/585 Spectroradiometer concept of convenience, the Model 585-60 Series Detector Heads have the quick-disconnect, accurate optical-alignment capability of bayoneting to the Model 585-11 Monochromator Housing (see Figures 3 and 4), ensuring optimum optical coupling throughout the system. In addition, to allow equal ease of use in left-to-right or right-to-left optical setups, the Model 585-00-60 Power Supply is completely reversible in its mating to both the Model 585-66 Detector Head and the Model 585-00-10 Series Adapters.

2.6.3 Physical Characteristics

Models 585-62, 585-64, and 585-66

Length:	12.5 inches
Width:	4.25 inches
Height:	5.25 inches
Weight:	5.9 pounds

Model 585-63

Length:	17.5 inches
Width:	8.0 inches
Height:	9.5 inches
Weight:	19.4 pounds

2.6.4 Optics

The Model 585-60 Series Detector Heads are designed to be coupled to the optical output of the system Monochromator with repeated accuracy. The Detector Heads incorporate an automatic safety shutter designed to prevent possible damage to the photomultiplier tube (PMT) in the event that the operator inadvertently disconnects the Detector Head from the Monochromator Housing without first turning off the PMT power (Section 4). The System has been designed so that the output beam of the Monochromator will just fill the active area of the PMT cathode surface, thereby producing maximum utilization of all incident light energy.

2.6.5 Calibration

A Spectroradiometer with a Model 585-60 Series Detector Head is calibrated to its sensitivity versus wavelength, thereby permitting absolute irradiant measurement of both continuous and pulsed light sources. To provide a quick, convenient method of PMT gain calibration, an internal reference source has been included in each Model 585-60 Series Detector Head. Power for this source is derived from the Model 580-11A or 580-12 Indicator Unit.

2.6.6 Radiometer Calibration

The Model 585-60 Series Detector Heads can also be calibrated as radiometers. In this configuration, a diffuser is used on the front of the Detector in the same manner as the Model 580-20A Series Detector Heads and the Monochromator Housing is omitted.

2.6.7 External Viewing

For the display of the PMT signal on other than the Indicator Unit meter, a BNC signal connector and a switch (INT/EXT) are provided. (This is a current output which may be terminated in an appropriate impedance.)

2.6.8 Model 585-62 Individual Features

The Model 585-62 High-Sensitivity Detector Head incorporates an S-20 photomultiplier tube and encompasses a spectral range of 200 to 800 nanometers (ultraviolet and visible). This Detector Head mounts directly atop the Model 585-00-60 Power Supply as shown in Figures 3 and 15. Operating and calibration instructions

are given in Sections 4 and 5, respectively.

2.6.9 Model 585-63 Individual Features

The Model 585-63 High-Sensitivity Detector Head (Figure 16) incorporates a thermoelectrically cooled S-1 photomultiplier tube and encompasses a spectral range from 350 to 1150 nanometers (visible and infrared). It operates in conjunction with a Model 585-00-63 Thermoelectric Controller, which provides power to the thermoelectronics and maintains the photomultiplier at a constant temperature (within $\pm 0.5^{\circ}C$). This thermoelectric cooling reduces the leakage (dark current) and noise to a level that allows accurate readings to be made of very small light quantities (as low as 10^{-12} W/cm^2 nm or joules/cm^2 nm). Within one hour, the Model 585-00-63 Controller stabilizes the photomultiplier temperature at approximately $-20^{\circ}C$. The Model 585-00-60 Power Supply plugs into the Controller instead of the Detector Head in this configuration (see Figure 17). Operating and calibration instructions are given in Sections 4 and 5, respectively.

Figure 17. Model 585-00-63 Controller Mounted on Model 585-00-60 Power Supply.

2.6.10 Model 585-64 Individual Features

The Model 585-64 High-Sensitivity Detector Head incorporates a solar blind photomultiplier tube and encompasses a spectral range of 200 to 400 nanometers (UV). This Detector Head mounts directly on top of the Model 585-00-60 Power Supply as shown in Figures 3 and 15. Operating and calibration instructions are given in Sections 4 and 5, respectively.

2.6.11 Model 585-66 Individual Features

The Model 585-66 High-Sensitivity Detector Head incorporates an S-10 photomultiplier tube and encompasses a spectral range from 200 to 750 nanometers (UV and visible). This Detector Head mounts directly on top of the Model 585-00-60 Power Supply.

2.7 MODEL 585-00-60 POWER SUPPLY (Model 580/585 Spectroradiometer)

The Model 585-00-60 Power Supply (Figures 15 and 17) is used with all of the High-Sensitivity Detector Heads. The power supply-detector head combination provides facility for controlling the operating voltage, thereby regulating the

photomultiplier gain and preserving the calibration of the overall system. The Power Supply operates from a standard 115V, 70 mA, 50- to 60-Hz line.

2.7.1 Physical Characteristics

Length:	10 inches
Width:	5.25 inches
Height:	2.25 inches
Weight:	3.7 pounds

2.8 MODEL 585-00-63 CONTROLLER (Model 580/585 Spectroradiometer)

The unit consists of a full-wave power supply and solid-state control circuitry. It is capable of delivering 80W to four thermoelectric cooling elements surrounding the photomultiplier tube. The desired temperature level can be set by adjusting a potentiometer located on the Controller chassis. However, this potentiometer is factory-adjusted to maintain a PMT constant temperature of approximately -20°C. A red (cooling) indicator lamp is provided on the side of the Controller. When this lamp is lit, it indicates the Controller is cooling; when it cycles on and off, it indicates the minimum temperature has been reached. The Controller and the Detector Head Power Supply are connected by inserting the Controller into the Power Supply via three banana plugs. Three 8-foot cables connect the Controller to the Model 585-63 High-Sensitivity Detector Head. Two are coaxial cables that supply high voltage to the PMT. The third cable carries power and control functions for the thermoelectric-cooling subsystem. The sole panel adjustment for this combination is the voltage-set potentiometer on the Power Supply. The Controller operates from a standard 115V, 1A, 50- to 60-Hz line.

2.8.1 Physical Characteristics

Length:	10.5 inches
Width:	5 inches
Height:	7.75 inches
Weight:	13.5 pounds

2.9 MODEL 580-26 SILICON DETECTOR HEAD (Model 585 Spectroradiometer System)

2.9.1 General

The Model 580-26 Detector Head (Figure 18) incorporates an EG&G SGD-444 silicon photodiode (1.0 cm^2 active area with planar diffused-guard ring construction) that enables measurements to be made of steady or pulsed light sources over the spectral region 400 to 1100 nm.

The Model 580-26 utilizes a quick-disconnect bayonet mount to ensure accurate optical alignment to the Model 585-11 Monochromator Housing. A high mass detector housing minimizes dark current drifts as a result of ranging temperatures. The physical characteristics of the Head are

Length:	2.5 inches
Height:	4 inches
Width:	4 inches
Weight:	3 pounds

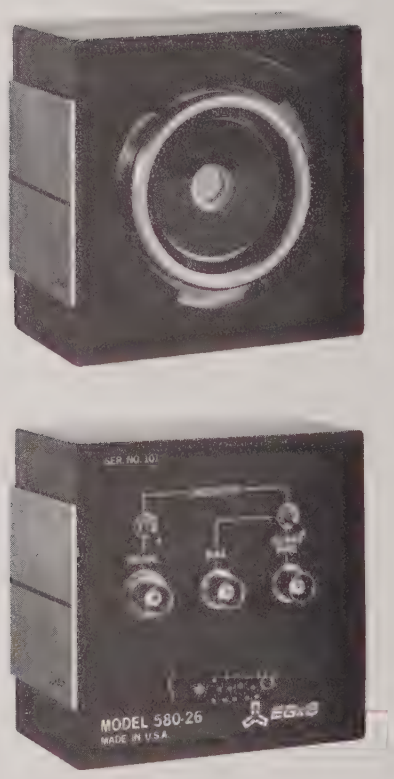


Figure 18. Model 580-26 Silicon Detector Head.

2.9.2 Functional Controls

The functional controls are located at the rear of the detector housing. The function of each control is described below.

(1) SIGNAL switch: Two-position toggle switch which provides a means to measure anode output current signal either with the Indicator Unit or an external instrument.

a. Indicator (up) position: Photodiode current is measured with the Indicator Unit.

b. Switch in down position: Photodiode current signal is measured with external instruments connected to the SIGNAL BNC terminal.

(2) GUARD RING and BIAS: Two-position toggle switch selects method of biasing guard ring and photodiode. For linear operation with low leakage and low noise operation, the guard ring should be at the same voltage potential as the signal load, but the two should not be connected.

a. Indicator (up) position: Guard Ring is at ground potential. Photodiode biased at -150V from power supply in the Indicator Unit.

b. Switch in down position: Allows external voltage to be applied to the Guard Ring with any suitable external d-c power supply through BNC-type connector. Allows biasing of photodiode (up to -200V) with any external d-c power supply through the center conductor of the BNC connector.

The large bias voltages are for a fast detector risetime of typically 10 ns. For slower applications, the bias voltage can be reduced and the S/N ratio improved. Thirty to forty volts is usually the region of bias voltage for optimum S/N ratio operation. Some near-infrared response

is sacrificed by reducing the bias voltage.

With a bias voltage on the photodiode, it is operating in the photoconductive mode. In theory, the limiting noise is shot noise generated by the dark current of the device,

$$In = (2eI_d \Delta f)^{1/2}$$

and thermal noise generated by the internal impedance of the device,

$$In = \left(\frac{4KT \Delta f}{R}\right)^{1/2}$$

where

In = RMS noise current in amps
e = charge of an electron 1.6×10^{-19} coulombs
I_d = dark current of device in amps
Δf = bandwidth in Hertz of measuring system

For low-frequency operation, R = 100 M with the Guard Ring in use and R = 5 M without the Guard Ring. The total noise is the RMS sum of both noise sources.

$$In = \left(2eI_d \Delta f + \frac{4KT \Delta f}{R}\right)^{1/2}$$

where

K = Boltzmann's constant 1.38×10^{-23} joules/^{o}Kelvin
T = temperature of device in degrees Kelvin
R = internal resistance of device in ohms

The theoretical noise limit is approached with the Synchronous Amplifier System.

The practical noise limit for operation with the Model 580-11A or 580-12 Indicator Units is the drift of the dark current with temperature fluctuations. The dark current doubles for an approximate temperature increase of 10^{o}C.

The detector can be operated at zero volt bias by leaving the Guard Ring open and connecting the bias lead to the same voltage potential as the signal lead. This reduces the leakage current to zero, but the thermal noise remains. For noise purposes, the detector looks like a 5-Mohm resistor at zero volt bias.

2.10 MODEL 585-55 IR DETECTOR HEAD (Model 585 Spectroradiometer)

2.10.1 General

The Model 585-55 IR Detector Head (Figure 19) incorporates a cooled lead sulfide photoconductor that permits measurements of steady-light sources over the spectral region 0.7 to 3.2 microns. The PbS detector is mounted in a vacuum chamber which is thermoelectrically cooled by a proportional d-c controller to $0^{o}C \pm 0.01^{o}C$ for ambient temperature range of 0 to 35^{o}C. The detector cool-down time is 5 minutes for an ambient temperature of 25^{o}C.

2.10.2 Mechanical

The Model 585-55 IR Detector Head incorporates a quick-disconnect bayonet

Figure 19. Model 585-55 IR Detector Head.

mount which ensures accurate optical alignment to the Model 585-11 Monochromator Housing. The physical characteristics of the Head are

Length:	12-1/2 inches
Width:	5-1/4 inches
Height:	7-1/2 inches
Weight:	15 pounds

2.10.3 Optics

The Model 585-55 IR Detector Head is designed to be coupled to the optical output of the System Monochromator with repeated mechanical accuracy. Light enters the Detector Head through a water-free quartz window. Located directly behind this entrance window is the vacuum chamber and a cooled aperture. The system has been designed so that the output beam of the Monochromator will slightly overfill the active area of the PbS surface, thereby producing nearly maximum utilization of all incident light energy and avoiding problems with sensitivity variations across the detector.

2.10.4 Functional Controls

A single POWER ON-OFF switch is located on the rear of the Detector Housing. In the ON position, power is supplied to operate the thermoelectric cooling unit. The Model 585-55 Detector Head derives its power from the Synchronous Amplifier and draws 520 mA while cooling and 370 mA once its temperature stabilizes at $0^{o}C$.

2.10.5 Detector Noise

For noise purposes, the detector looks within a factor of 2 like a 1-Mohm resistor at $0^{o}C$. It has typically a noise current of about 1.7×10^{-12} peak to peak amps/$Hz^{1/2}$.

2.11 MODEL 585-32 BEAM INPUT OPTICS (Model 580/585 Spectroradiometer)

The Model 585-32 Beam Input Optics (Figure 20) consists of a cylinder containing a pair of diffuser discs, an aperture, two light baffles, and a collective lens. The diffuser discs are made of quartz and are mounted together with all surfaces ground except the outside-front surface (the latter is polished to allow easy cleaning of fingerprints and dirt). The diffuser discs and the collective lens are made of fused quartz so that they can be used throughout the entire spectrum (200 to 3200 nm). The field of view of the Beam Input Optics is 5^{o}, and the source to be measured must be within this field ($\pm 2.5^{o}$). Any unwanted energy beyond the 5^{o} field should be compensated out or eliminated. The

Figure 20. Model 585-32 Beam Input Optics.

diffuser discs which must be fully illuminated disperse the beam of light so that it uniformly illuminates the Monochromator entrance slit.

The two light baffles prevent stray light from reaching the collection lens. The second light baffle is prestressed to compensate for dimensional variations in the mating pieces within the cylinder.

The Model 585-32 Beam Input Optics attaches to the Model 585-11 Monochromator Housing by a bayonet-type coupling. Its dimensions are:

Length:	5 inches
Diameter:	3-3/4 inches
Weight:	1-3/4 pounds

2.12 MODEL 585-11 MONOCHROMATOR HOUSING (Model 580/585 Spectroradiometer)

2.12.1 General

The Model 585-11 Monochromator Housing (Figure 21) is a cast-aluminum unit (Bausch & Lomb) which receives the grating assembly (see subsection 2.13), entrance slit, and exit slit (see subsection 2.14). The Housing contains the corrector lens, concave mirror, and coupling facilities for connecting appropriate Beam Input Optics and Detector Head. Figure 22 shows schematically the optical configuration of the Monochromator Housing, with grating, slits, and beam input optics attached.

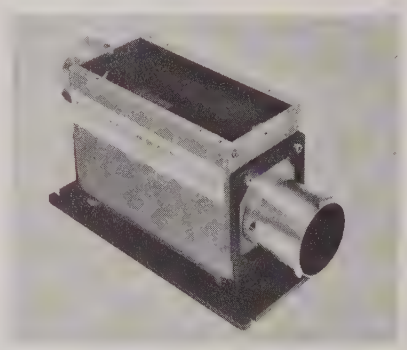


Figure 21. Model 585-11 Monochromator Housing.

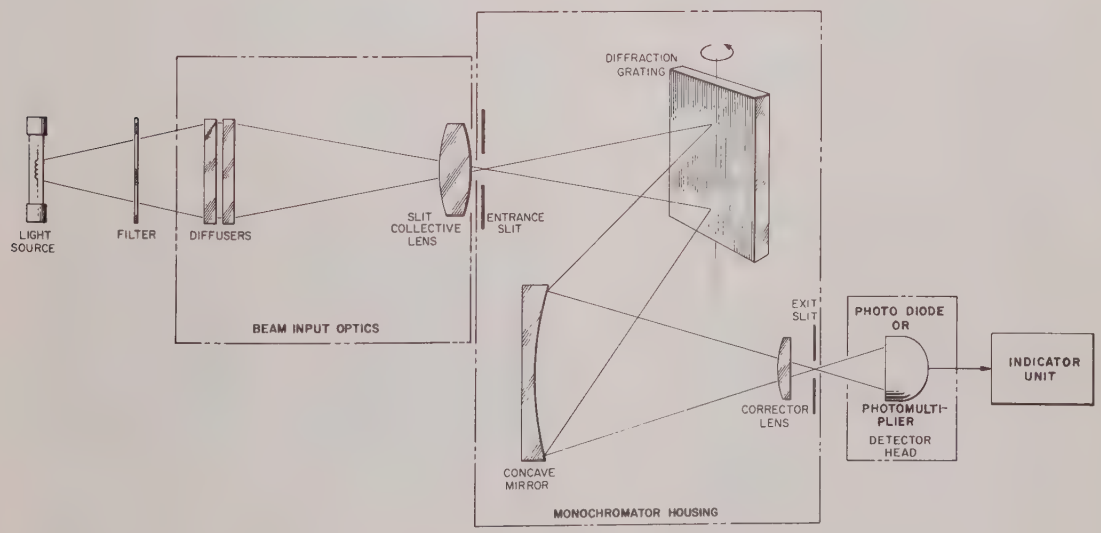


Figure 22. Optical Schematic of a Spectroradiometer.

2.12.2 Principles

To explain the principles of the Monochromator function, it is necessary to treat the housing, grating, and slits as a single package. Light emanating from a source passes through the diffuser system (Beam Input Optics) and is directed by the collective lens into the Monochromator Housing via the entrance slit. The light incident on the diffuser is imaged by the collective lens of the Beam Input Optics onto the grating, completely filling the grating area with light. The light incident on the plane diffraction is angularly dispersed according to wavelength. The grating can be rotated to direct any selected wavelength bundle onto a concave mirror. The mirror collects the light and, with the help of a quartz corrector lens, forms an image of the entrance slit on the exit slit.

The image at the entrance slit is reduced in size at the exit slit by a factor of 0.56. The exit slit, therefore, has a width and height which are 56% of those of the entrance slit. The height is maintained at the correct ratio in the variable slits, but the width should be kept in this same 0.56 relationship for best results. Only one wavelength which strikes the concave mirror results in an image which falls precisely on the exit slit. All other wavelengths produce images which are to the right or left of the exit slit. The lateral separation of these images at the exit slit is measured as the dispersion (expressed in nanometers/millimeter) of the Monochromator.

The exit-slit width and the dispersion, in combination, determine the bandpass, or spectral purity, of the system. The optical system is of the noncollimated type and provides a nearly monochromatic diverging exit beam of f/3.5.

As discussed above, the entrance-slit image at the exit slit is 56% of the source size at the entrance slit. It is necessary to multiply the width of the exit slit by 1.78 to obtain the proper width of the entrance slit. Using this ratio, only the selected single wavelength can pass through the system at its full intensity. All other wavelengths will be imaged so that a portion of each is excluded by the exit-slit jaws.

The combination of the grating and a particular pair of slits determines the dispersion in any system. The dispersion values for the slits in relation to the various gratings are stated in Table 5. In the case of variable slits, the 56% relationship of output to input must be kept constant and the dispersion expressed in terms of the exit-slit width as units of nanometers per millimeter (nm/mm) for each grating. For example, if one were using a Model 585-22 Grating (visible region) with Model 585-20-24 Variable Slits (subsection 3.4) and the

Table 5. Dispersion Values.

Model No.	SLITS		GRATINGS			
	Entrance	Exit	Effective Width			
	Width	Width	300-800 nm 585-22	700-1600 nm 585-23	180-400 nm 585-24	1.4-3.2 μm 585-25
585-20-21	5.36 mm	3.00 mm	20 nm	40 nm	10 nm	80 nm
585-20-22	2.68 mm	1.50 mm	10 nm	20 nm	5 nm	40 nm
585-20-23	1.34 mm	0.75 mm	5 nm	10 nm	2.5 nm	20 nm
585-20-24	Variable	Variable	6.4 nm/mm	12.8 nm/mm	3.2 nm/mm	25.6 nm/mm

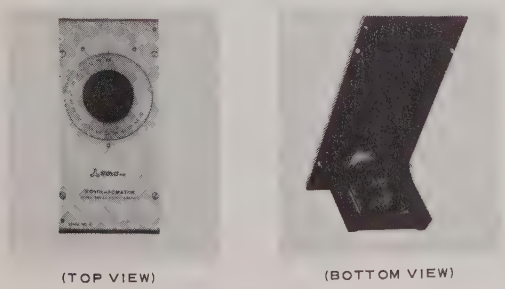
requirement demanded the dispersion to be held at 16 nanometers, the exit-slit would have to be 2.5 millimeters with the entrance-slit setting at 4.47 millimeters.

2.12.3 Physical Characteristics (With Grating)

Length: 10.75 inches
Width: 5.00 inches
Height: 7.00 inches
Weight: 8.2 pounds

2.13 MODEL 585-20 SERIES GRATINGS (Model 580/585 Spectroradiometer)

Model 585-20 Series Gratings (Figure 23) are used with the Model 585-11 Monochromator Housing in all Spectroradiometer System configurations. Four different gratings are available (Table 1); selection is determined by the desired light-range response. The gratings, when inserted, form the top of the Monochromator Housing. (Four captive screws on the grating top secure the grating assembly to the Monochromator Housing.) Filters are commonly used with these gratings to eliminate the second and higher harmonics of the fundamental wavelengths (refer to subsection 2.15).



(TOP VIEW) (BOTTOM VIEW)

Figure 23. Model 585-20 Series Grating.

CAUTION

The Model 585-11 Monochromator Housing should never be left without a cover (i.e., with grating assembly removed) for even short periods of time because of danger of collecting dust or other foreign material in the housing. When the Monochromator Housing is not in use, the slit openings should be covered by having a cap or mating hardware attached to them. Spare grating assemblies must be kept in their storage boxes. The first-surface aluminized optical elements are very susceptible to permanent damage from atmospheric contaminants or accidental physical contact. Never attempt

mechanical cleaning of mirrors or gratings. Blowing away of dust particles is permissible only with prepackaged aerosol cans of dry air. Moisture in the breath may coat optical surfaces.

Internal optical adjustments in the Monochromator Housing and grating assemblies have been made at the factory using specialized fixtures. Disassembly of these units, other than as directed in this manual should not be attempted.

The Model 585-22 Grating is a 1350-groove-per-millimeter grating covering the visible region from 350 to 800 nanometers in the first order. It is blazed at 500 nanometers. The reciprocal linear dispersion is 6.4 nanometers per millimeter. The smallest scale division for this grating assembly is 5 nanometers.

The Model 585-23 Grating is a 675-groove-per-millimeter grating covering the infrared region from 700 to 1600 nanometers in the first order. It is blazed at 900 nanometers. The reciprocal linear dispersion is 12.8 nanometers per millimeter. The smallest scale division for this grating assembly is 10 nanometers.

The Model 585-24 Grating is a 2700-groove-per-millimeter grating covering the ultraviolet region from 180 to 400 nanometers in the first order. It is blazed at 250 nanometers. The reciprocal linear dispersion is 3.2 nanometers per millimeter. The smallest scale division for this grating assembly is 2 nanometers.

The Model 585-25 Grating is a 337.5-groove-per-millimeter grating covering the infrared region from 1.4 to 3.2 microns in the first order. It is blazed at 2.0 microns. The reciprocal linear dispersion is 25.6 nanometers per millimeter. The smallest scale division for this grating is 20 nanometers.

The wavelength accuracy of each grating is ±1% of its blaze wavelength. The accuracies are as follows:

Model 585-22	±5 nm
Model 585-23	±9 nm
Model 585-24	±2.5 nm
Model 585-25	±20 nm

All of these gratings produce some scattered light. The amount of scattered light in a system varies greatly depending on the spectral characteristics of the source and detector. Methods for eliminating scattered light are discussed in subsection 4.7.

2.14 MODEL 585-20-20 SERIES FIXED SLITS (Model 580/585 Spectroradiometer)

Model 585-20-20 Series Fixed Slits (Figure 24) are used in all Spectroradiometer System configurations. Three groups of Fixed Slits are furnished with

each system. Each group contains one "entrance slit" and one "exit slit," precut to furnish the correct dispersion at the desired wavelength. To avoid a mismatch, the actual width of the fixed slit in millimeters is engraved on the face of each slit. A detailed explanation of slit function is incorporated in the Model 585-11 Monochromator Housing discussion (subsection 2.12). The Fixed Slits are mounted by two screws to the flat shoulder inside the bayonet-type coupling at the front and back of the Model 585-11 Monochromator Housing.

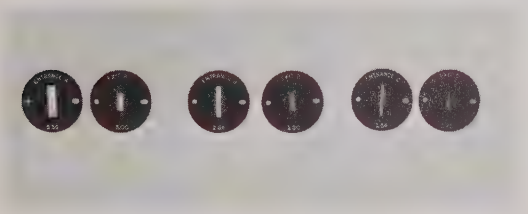


Figure 24. Model 585-20-20 Series Fixed Slits.

2.15 MODEL 585-20-10 SERIES FILTERS (Model 580/585 Spectroradiometer)

Order sorting filters are furnished with each Model 580/585 Spectroradiometer System. The filter combination and ranges are stated in Table 6.

These filters (shown in Figure 25) eliminate the higher order of wavelengths produced by the gratings in the Monochromator Housing. For example, the Model 585-20-16 Filter, which is used in the region between 380 and 550 nanometers, has zero transmission below 340 nanometers. The wavelengths whose higher orders occur at 550 nanometers are 275, 183.3, 137.5, 110 nanometers, etc., and would be eliminated with the use of the Model 585-20-16 filter.

The filters are marked with the RETMA Color Code to show their CS

Table 6. Filter Combinations and Ranges

MODEL NO.	CORNING NO.	REGION	RANGE (nm)
None	None	Ultraviolet	200 – 300
585-20-17	7-54	Ultraviolet	300 – 400
** 585-20-15	9-54	Ultraviolet	300 – 400
585-20-17	7-54	Visible	350 – 380
585-20-16	0-52	Visible	380 – 550
585-20-12	3-69	Visible	550 – 700
585-20-13	2-64	Visible	700 – 800
585-20-13	2-64	Near IR	700 – 1000
585-20-14	7-56	Near IR	1000 – 1600
585-20-18	* 1.2 μ Cut-on	Intermediate IR	1400 – 2000
585-20-19	* 1.8 μ Cut-on	Intermediate IR	2000 – 3200

*Not Corning Filters

**Model 585-64 Detector Head Only

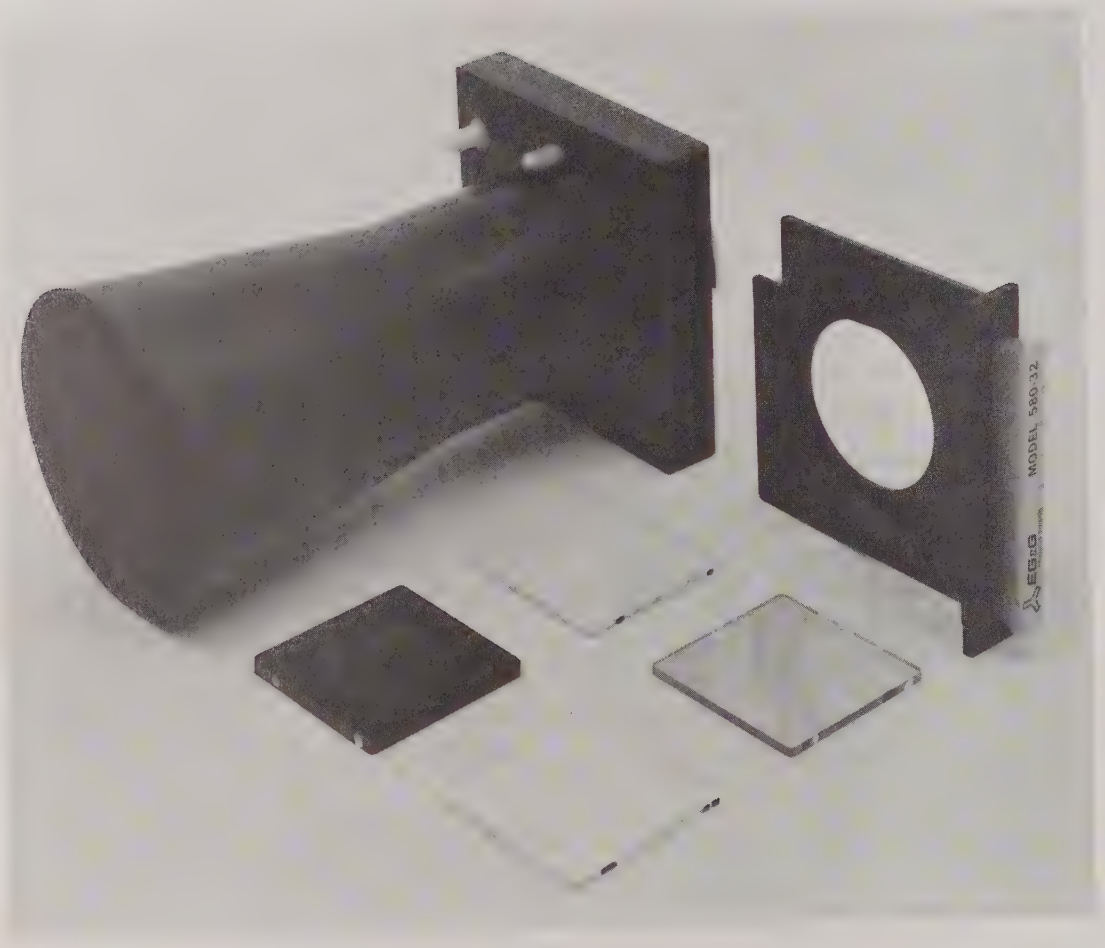


Figure 25. Model 580-32 Hooded Filter Holder with Model 585-20-10 Series Filter.

number and serial number. The colors start from the left-hand side of the filter edge and show the CS number as three color bands (e.g., CS-0-52 shows black, green, and red). The serial number is the one, two, or three color bands in the middle of the edge. Calibration certificates accompanying each system state the serial number of the filter used during calibration.

2.16 MODEL 580-32 HOODED FILTER HOLDER (Model 580 Radiometer and Model 580/585 Spectroradiometer System)

This combination filter-holder-and-viewing-hood (Figure 25) adds two capabilities to the Radiometer and Spectroradiometer

Systems. The filter-holder portion can be used to mount any of the order sorting filters supplied with the Model 580/585 Spectroradiometer System, or any special narrow-bandpass filters used with Model 580 Radiometer System applications. Two filters, if required, can be inserted into one holder. Round, special filters not exceeding 2.75 inches (70 mm) in diameter and square, special filters not exceeding 2.0 inches (51 mm) in side dimension can be mounted without modifications. Spring clips, permanently fastened to the slide-in filter holder, position and retain the filters.

The viewing-hood portion minimizes the effects of scattered and ambient light when measuring light from specific sources. The cone-shaped hood restricts the field of view to 14°. This is equivalent to a one-foot diameter source at a distance of four feet.

Both portions of the Model 580-32 Hooded Filter Holder have a black matte finish on the interior surfaces to prevent reflected-light problems. A bayonet-type coupling enables the unit to be quickly attached to the various Detector Heads of the Radiometer System and to the Beam Input Optics of the Spectroradiometer System. A shutter-release pin, installed in the filter holder housing, enables remote shutter control without decoupling when the Hooded Filter Holder is directly coupled to a Model 585-60 Series High-Sensitivity Detector Head.

2.16.1 Physical Characteristics

Length:	7.65 inches
Width:	4.00 inches
Height:	4.5 inches
Weight:	0.9 pound

2.17 MODEL 585-00-10 SERIES ADAPTER PLATES (Model 580/585 Spectroradiometer)

Three different adapter plates are available for the Model 580/585 Spectroradiometer System (see Table 1). The exact plate required for a particular system depends on the components of that system.

The Model 585-00-11 Adapter Plate (shown in Figures 2 and 3) is the basic adapter used in most system configurations. It consists of a plate for mounting the Model 585-11 Monochromator Housing and one of the following Detector Heads on a common base:

1) Model 580-22A Detector Head
2) Model 580-23A Detector Head
3) Model 580-25A Detector Head
4) Model 580-26 Detector Head
5) Model 585-62 High-Sensitivity Detector Head
6) Model 585-64 High-Sensitivity Detector Head
7) Model 585-66 High-Sensitivity Detector Head

The plate utilizes knurled thumbscrews to secure the Monochromator Housing and Detector Head. It has tapped holes to permit tripod mounting (1/4-20 thread).

The Model 585-00-12 Adapter (shown in Figure 4) is used for mounting the Model 585-63 High-Sensitivity Detector Head or the Model 585-55 IR Detector Head and Model 585-11 Monochromator Housing on a common base. However, its versatility is such that it can also be used to mount any of the other Model 585-60 Series High-Sensitivity Detector Heads and the Model 580-20 Series Detector Heads used in conventional Model 580/585 Spectroradiometer applications (see Table 1). This adapter also utilizes knurled thumbscrews to secure the mounted components.

The Model 585-00-13 Adapter (Figure 26) is designed to mount any Model 580 Radiometer or 580/585 Spectroradiometer System with the Model 585-36 Telescope. All systems must be preassembled before being mounted to the Adapter. In all configurations, the Telescope attaches to the silk-screened (front) end of the plate with two knurled thumbscrews. There are two removable posts with thumbscrews (Figure 27) provided with the Adapter for mounting a Model 580 Radiometer System. The mounting posts are used in either of two locations (A or B on Figure 26). The forward location (A) is used for mounting the Model 585-66 (S-10) High-Sensitivity Detector Head or any of the Model 580-20A Series of Detector Heads. The mounting posts in the second location (B) are used for mounting the Model 585-63 (S-1) High-Sensitivity Detector Head.

The middle set of permanently mounted knurled thumbscrews are used to hold the Model 585-66 (S-10) High-

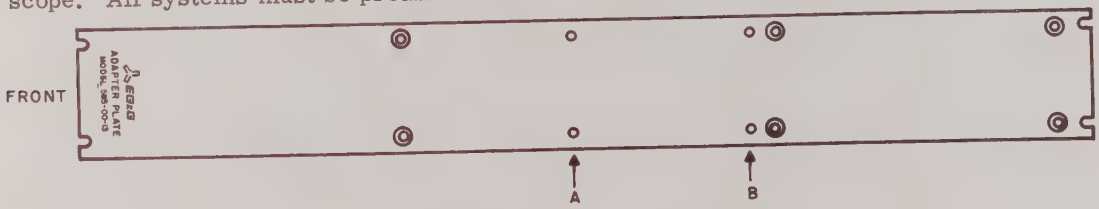


Figure 26. Model 585-00-13 Adapter.

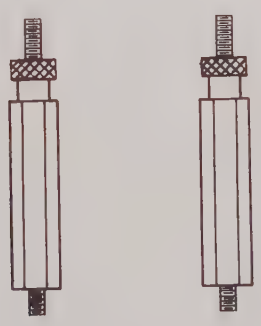


Figure 27. Removable Posts Provided with the Model 585-00-13 Adapter.

Sensitivity Detector Head or any of the Model 580-20A Series Detector Heads when a Spectroradiometer System is attached to the Telescope. In this mounting configuration, the Monochromator is suspended between the Telescope and the Detector Head.

The rear set of permanently mounted knurled thumbscrews is used to hold the Model 585-63 (S-1) High-Sensitivity Detector Head when an S-1 High-Sensitivity Spectroradiometer System is attached to the Telescope. The Monochromator is again suspended between the Telescope and the Detector Head.

The Adapter has tapped holes to permit tripod mounting (1/4-20 thread).

2.18 MODEL 585-42 CHOPPER

2.18.1 General

The Model 585-42 Chopper (Figure 28) uses a synchronous hysteresis motor to drive a low emissivity chopper blade to produce a fixed chopping frequency of 87 Hz. The blade opening is large with respect to the Monochromator input slit and produces a nearly square waveform of chopped radiation regardless of standard slit size used. The reference signal for the Synchronous Amplifier is generated within the Chopper by a source-detector combination producing a signal of fixed frequency and phase.

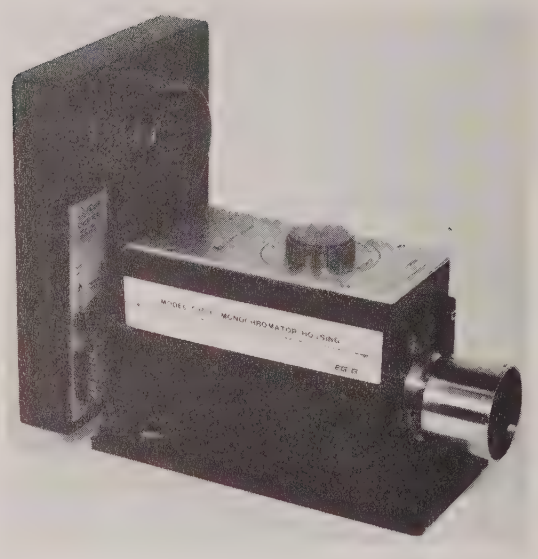


Figure 28. Model 585-42 Chopper.

2.18.2 Mechanical

The Model 585-42 Chopper mounts directly onto the front of the Model 585-11 Monochromator Housing in place of the front bayonet mount. The following steps should be followed when attaching the Model 585-42 Chopper to the Model 585-11 Monochromator Housing:

1) Remove the two 1" 6-32 binder head screws holding the front bayonet in place on the Monochromator Housing.

2) Remove the bayonet mount and store in safe place for possible future use.

3) Remove the two 3/8" 8-32 fillister head screws from the front of the Chopper Housing (save the screws).

4) Mount the Chopper on the Monochromator Housing lining up the two 1 1/2" 6-32 flat head screws in the Chopper with the two threaded holes in the Monochromator Housing.

5) Tighten the screws into place.

6) Replace the two 3/8" 8-32 fillister head screws removed from the Chopper Housing (step 3).

To interchange the slits once the Chopper is in place, reverse the procedure in steps 3 through 6 above.

2.18.3 Physical Characteristics

Length:	2.25 inches (5 inches with motor)
Height:	10.5 inches
Width:	8.25 inches
Weight:	7.8 pounds

2.18.4 Functional Controls

A single POWER ON/OFF switch is located on the rear of the Chopper Housing. In the ON position, power is supplied to the Chopper motor from the Synchronous Amplifier. The Model 585-42 Chopper draws 220 mA.

2.18.5 Noise

The internal reference of the chopped system is the blade of the Chopper. Since the blade is enclosed in a housing at ambient temperature, it will appear as a nearly ideal blackbody at ambient temperature regardless of the blade surface.

The signal current, due to the Chopper blade at 300°K, from the Model 585-55 PbS Detector, in a Spectroradiometer System at 3.2 micrometers is about 1×10^{-13} amp. Since this current level is well below the noise level of the PbS Detector, 2×10^{-12} amp at 1 Hz Δf, the system will never be used where the temperature blade will cause signal errors.

The signal current when the Chopper blade is viewed in the visible region is orders of magnitude less than in the IR. The Chopper blade is belt-driven from a synchronous hysteresis motor. The motor will remain locked to the primary a-c source, which has short-term stability. The belt allows the blade to be turning at a frequency which will not be affected by the primary a-c source or any of its harmonics.

SECTION 3

DESCRIPTION OF ACCESSORIES

3.1 GENERAL

This section contains a description of each of the accessories for the four basic systems (Section 1.1) and an explanation of the principal operational features of each. Illustrations of the accessories are provided.

NOTE

Keep in mind throughout these instructions that many accessories are common to more than one system.

3.2 MODEL 580-00-11 NARROW-BEAM ADAPTER/LASER ATTENUATOR (Model 580 Radiometer System)

The Narrow-Beam Adapter/Laser Attenuator (Figure 29) is an accessory that can be used with the Model 580 Radiometer System, the Series 585-60 High-Sensitivity Detector Heads, and the 580-26 Silicon Detector Head. It is designed for making measurements of narrow beams of light or coherent laser beams with diameters less than 5/8 inch. It bayonet-couples to the front of the Detector Head housing. It assures full illumination of the diffuser disc in applications where a light source beam under evaluation would not ordinarily cover the full area. Light accepted from a narrow beam is redistributed over the entire active area of the diffuser disc. This capability validates the detector calibration and permits detector response to remain directionally noncritical. The input beam must be fully contained within a 5/8-inch diameter circle at the center of the diffuser to ensure 100% transfer of the energy to the detector diffuser.

The unit also provides for an additional fixed attenuation of the incident light so that measurements can be made of relatively high laser intensities without overdriving the detector. The attenuation of the accessory is completely calibrated

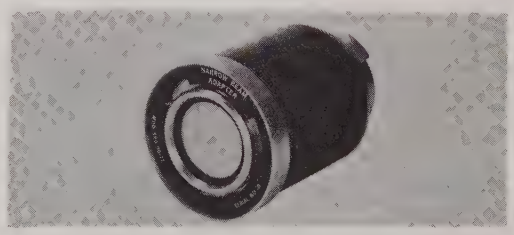


Figure 29. Model 580-00-11 Series Narrow-Beam Adapter/Laser Attenuator.

as a function of wavelength to ensure continued absolute measurement capability. The attenuation factor is in terms of

$$\frac{W/cm^2 \text{ out}}{W \text{ in}}$$

This factor when multiplied by the appropriate detector sensitivity in terms of

$$\frac{Amp}{W/cm^2}$$

yields a combined sensitivity in terms of ampere/watt (or coulombs/joule). The purpose of this unique calibration is to allow the laser to be measured in absolute power or energy terms rather than in the power density and energy density terms of the standard detector calibration.

This accessory can be utilized with most diode and gas lasers. It can also be used with most ruby and neodymium laser systems with peak outputs up to approximately 100 megawatts.

3.2.1 Physical Characteristics

Length:	5-1/8 inches
Diameter:	3.75 inches
Weight:	1.3 pounds

3.3 MODEL 580-00-12 LASER-BEAM SAMPLER (Model 580 Radiometer)

The Laser-Beam Sampler (Figure 30) is used for measuring, with a minimum amount of interference, narrow beams of high-intensity light such as those produced by ruby and neodymium laser systems. It is used in conjunction with the Narrow-Beam Adapter/Laser Attenuator and permits measurements of peak powers between 100 megawatts and 10 gigawatts and measurements of integrated energies as high as 10,000 joules. This accessory directs a calibrated percentage of the laser output ($\approx 0.3\%$) onto the Narrow-Beam Adapter diffuser while allowing approximately 80% of the output to be utilized for other experimental studies. An alignment mirror near the input window allows autocollimating of the Laser-Beam Sampler with a light source. Because of a unique design feature, polarization of the light beam will not affect the measurements. Calibration data (see certificate) provides through-beam transmission and measurement of beam attenuation. The Laser-Beam Sampler attaches directly (bayonet coupling) to the Model 580-00-11 Narrow-Beam Adapter/Laser Attenuator. Its physical characteristics are:

Length:	7 inches
Width:	4-3/4 inches
Height:	5-3/4 inches
Weight:	3 pounds

Figure 30. Model 580-00-12 Laser-Beam Sampler.

3.4 MODEL 585-20-24 VARIABLE SLITS (Model 580/585 Spectroradiometer)

Variable Slits (Figure 31) can be used in all Spectroradiometer System configurations as an optional item. A detailed explanation of slit operation is furnished in the discussion on the Model 585-11 Monochromator Housing in subsection 2.12. The Variable Slits are mounted directly to the housing face behind the bayonet-type couplings. Before the Variable Slits are installed, the bayonet-type couplings must be removed by turning off the two retaining screws. The Variable Slits are then held to the housing face while the bayonet-type couplings are reaffixed.

Figure 31. Model 585-20-24 Variable Slits.

3.5 MODEL 585-11-11 WAVELENGTH TRANSDUCER (Model 580/585 Spectroradiometer System)

The Wavelength Transducer (Figure 32) can be used in all Spectroradiometer System configurations. To obtain a direct plot of wavelength versus intensity, an X-Y recorder is used in conjunction with the recorder output (REC OUT) in all Model 580-10 Series Indicator Units and

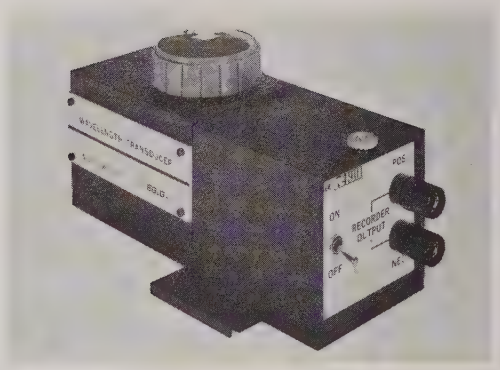


Figure 32. Model 585-11-11 Wavelength Transducer.

the Wavelength Transducers (see Figure 33). The Wavelength Transducer provides a voltage output to drive the X-coordinate of the X-Y recorder in a linear proportion to the wavelength setting while the Indicator Unit drives the Y-coordinate. Thus, a direct spectrum plot of any light source can be obtained.

The Wavelength Transducer mounts onto the grating on the top of the Model 585-11 Monochromator Housing. After the initial step (subsection 4.6), utilization of a special adapter ring allows the Wavelength Transducer to be used with all four gratings.

A side-mounting Wavelength Transducer is utilized in systems using the Model 585-42 Chopper, since the Chopper motor interferes with the normal mounting of the Wavelength Transducer. Its physical characteristics are:

Length:	7-1/4 inches
Width:	4 inches
Height:	3-1/4 inches
Weight:	6 ounces

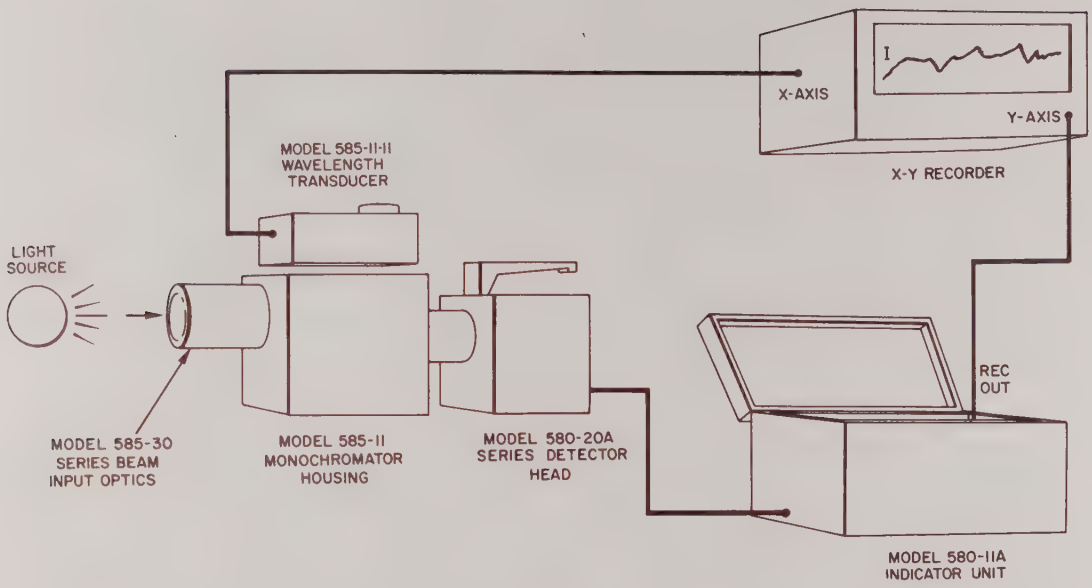


Figure 33. Equipment Setup for a Direct Plot of Wavelength Versus Intensity.

3.6 MODEL 580-00-30 SERIES PHOTOMETRIC FILTERS

Model 580-00-30 Series Photometric Filters are used with the Models 580-22A, 580-25A, 585-62, and 585-66 Detector Heads to alter the response of these systems to approximate the photopic (eye response) curve.

The Model 580-00-31 Photometric Filter is used in conjunction with a Model 580-25A Detector Head. The filter is mounted in a threaded ring which screws directly into the front of the Detector Head. The Model 580-00-32 Photometric Filter is used in conjunction with the 585-66 Detector Head. The filter is 2 inches square and mounts in the Model 580-32 Hooded Filter Holder. The Model 580-00-33 Photometric Filter is used in conjunction with either a 580-22A or a 585-62 Detector Head. The filter is 2 inches square and mounts in the Model 580-32 Hooded Filter Holder.

The photometric calibration of all Detector Heads is made using a $3000^{o}K$ photometric standard. The calibration is expressed in ampere/lumen/ft^2 and ampere/lumen/cm^2. The calibration accuracy is ±8% of absolute for sources whose color temperatures range from $2500^{o}K$ to $6000^{o}K$. On request, a photometric calibration for the Model 580-25A Detector Head can be provided against a $6000^{o}K$ flash standard.

3.7 MODEL 585-00-15 TRIPOD

The Model 585-00-15 Tripod is a complete unit with a Geared Head and Dolly (Figure 34). This unit is manufactured by Quick-Set, Inc. and has been chosen because of its many excellent engineering features, especially its capability for use with EG&G's Radiometer or Spectroradiometer System.

The Tripod leg sections slide in nylon bushings for smooth operation and minimum wear. A nylon-brushed brake ring, screw actuated, locks leg sections at any extension.

The Strut Collar slides in nylon bushings on the central strut tube and locks to hold legs at any desired spread.

Figure 34. Model 585-00-15 Tripod.

The Elevator Mechanism provides vertical adjustment from a fraction of an inch to full rise by turning the hand wheel. Standard gearing provides 5/32 inch rise per turn.

The Column, a heavy-wall tube with rack teeth machined from the solid, is raised and lowered by a steel pinion which meshes with the rack. The pinion is driven by a hand wheel through a steel-to-bronze worm-gear reduction. Ball-bearings carry the thrust load on the worm to ensure easy operation.

The Column is guided by an anti-friction bushing in the upper end of the elevator body. The lower end of the Column carries an anti-friction bushing which bears on the inside of the Strut Tube. A brake holds the Column securely at the desired height and locks it against side shake to make it a rigid extension of the tripod.

The Elevator column terminates in a socket with a precision bore. A steel insert has a conical recess in one wall with a hole in the wall opposite.

Pan heads and accessories have a flanged stud with a transverse threaded hole in which is carried a cone-point set screw (1.245 inches in diameter by 1-1/2 inches long).

When the set screw is advanced (hex wrench passes through holes in column and stud), the point of the set screw entering the recess in the socket takes up all

clearance in the bore, and pulls the flange on the stud tight against the face of the socket (Figure 35).

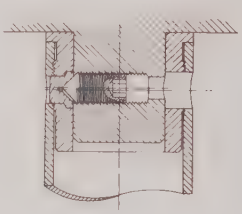


Figure 35. Flanged Stud Showing the Position of the Setscrew.

The Geared Head (Figure 36) can be rotated continuously (360°). It is supported on two axially spaced ball bearings (Figure 37-5, 5) mounted on a large steel shaft (4). Pre-load on bearings eliminates shake, yet retains freedom of motion – heavy loads move at a finger touch. A screw-operated spring-loaded brake (212) bears on a large diameter brake drum to provide adjustable drag or positive lock.

Figure 36. Geared Head Mounted on Tripod.

The head tilts on two widely spaced roller bearings (28, 28). Multiple contact brake (18, 25) acting on side plates provides adjustable drag, or positive lock.

Torsion springs (31, 32) resist tilting in either direction, compensate for torque of load, and prevent nose diving.

A circular bubble level (10) is mounted in the head body and precisely aligned with the vertical axis.

Pan and tilt are operated by handwheels with shafts placed at right angles so that both can be operated simultaneously. The wheels can be spun for rapid motion or "inches" for small adjustments. Worm gearing is irreversible; and in addition, positive locks are provided on both pan and tilt to guard against accidental movement.

Large knobs control friction on pan and tilt. First tightening adjusts spring pressure for graduated drag. Additional tightening produces a rigid lock.

The mounting plate is faced with elastic anti-slip material and is movable forward and backward 3-1/2 inches to aid in balancing the system. The plate slides in dove-tail-ways with positive stops and has a clamp to lock the plate in intermediate positions.

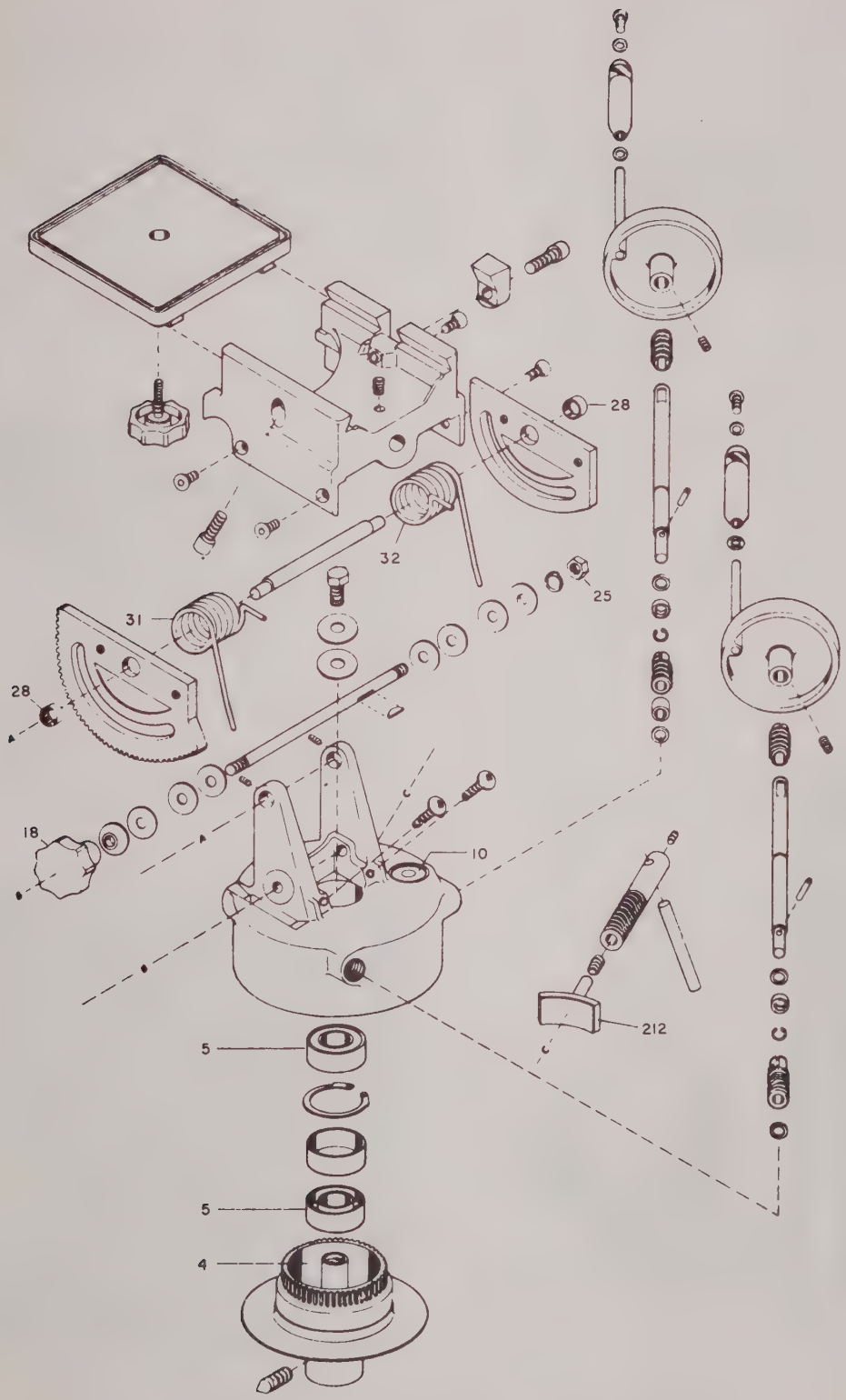


Figure 37. Geared Head - Parts Breakdown.

3.7.1 Specifications

Tripod

Rated Load	75 lbs. max.
2-section legs, dia.	1¾" & 1½"
Max. height, legs extended & spread, Elevator up	73"
Min. height, legs telescoped & spread, Elevator down	33"
Max. spread at max. height – dia. of circle	75"
Max. spread at min. height – dia. of circle	45"
Elevator Column 2" dia. – rise	18"
Diameter of foot plate	4"
Telescoped size	9½" x 11½" x 41"
Weight	19 lb.

Geared Head

Camera plate 4" x 4"	Plate adjustment 3½"
Camera screw	¼" – 20
Vertical tilt 45° up, 60° down	Pan 360°
Tilt gear ratio 1:129	Pan gear ratio 1:96
Height 6¾"	Weight 7 lbs.

Load Range Pounds	Torque Rate lb. in. per degree	Max. Tilt Down Degrees
25-40	5	60

Dolly (Figure 38)

Caster 4" x 1" (Capacity 500 lbs.)	Height 7"
Dia. of caster circle 45"	Weight 15 lbs.
Folds to 7" x 13" x 28"	

Figure 38. Model 585-00-15 Tripod and Dolly.

3.8 MODEL 585-35 SERIES FIBER OPTICS PROBE ASSEMBLIES

The Model 585-35 Series Fiber Optics Probe Assemblies are designed as accessories for use with the Radiometer or Spectroradiometer Systems (Figures 39 and 40). In most applications they are used with the High Sensitivity Detector Heads because of the lower levels of light available at the detector surface.

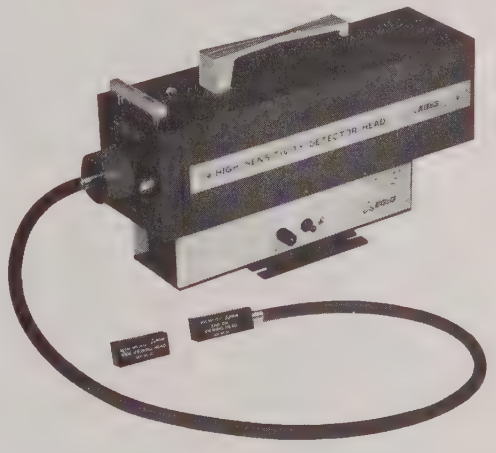


Figure 39. Model 585-35 Series Fiber Optics Probe Assembly.

Figure 40. Model 585-35 Series Fiber Optics Probe Assembly.

The optical system of the Probe Assemblies consists of a 1/8-inch diameter aperture (other sizes can be provided on special order) in front of an opal glass diffuser. This combination of aperture/diffuser gives a $\cos^{1.5}\theta$ response field of view. The light energy from the diffuser passes either directly (End-On Viewing Head), or through a 90^{o} reflecting prism (Side Viewing Head), into a 1/4-inch diameter, 36-inch long bundle of clad optical fiber. The light energy from the fiber bundles is directed either to a detector surface (Radiometer System) or through a lens (Probe Input Optics) focusing the energy through a monochromator to a detector surface (Spectroradiometer System). Since the 1/8-inch diameter input of probe viewing heads is small in relation to the 1-13/16-inch Radiometer input and the 5/8-inch Spectroradiometer input, approximately three decades less light reach the detector surface. As a result, the Fiber Optics Probe is mainly used with the Model 585-60 Series High Sensitivity Detector Heads. In some cases where small intense light sources (lasers) or very bright sources (xenon flash lamps) are measured, the Model 580-20 Series Photodiode Detector Heads can be used with the probe assemblies.

The Fiber Optics Probe Series consists of four basic assemblies:

1) The Model 585-35-11 End-On-Viewing Head (Figure 41) permits measurement of light parallel to the axis of the Fiber Optics Probe. An opal glass diffuser is used as the input element of

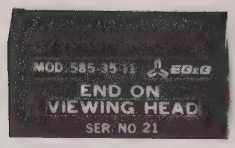


Figure 41. Model 585-35-11 End-On-Viewing Head.

the viewing head with a 1/8-inch aperture mounted in front of the diffuser. Smaller size apertures may be used for specific applications. The aperture plate is held on with two countersunk screws and the diffuser disc is held in a recess in the back of this plate. The head mounts to the Model 585-35-13 Fiber Optics Probe with two screws.

2) The Model 585-35-12 Side Viewing Head (Figure 42) permits measurement of light perpendicular to the axis of the Fiber Optics Probe. As above, an opal glass diffuser is used as the input element of the viewing head with a 1/8-inch aperture mounted in front of the diffuser.

Figure 42. Model 585-35-12 Side-Viewing Head.

Smaller size apertures may be used for specific applications. The aperture plate is held on with three countersunk screws, and the diffuser disc is held in a recess in the back of the plate. A small glass prism is used to reflect the light from the diffuser to the fiber bundle. A second plate provides access to the prism for any necessary cleaning.

NOTE

In returning the prism to the head, make certain that the image of the diffuser is centered when looking into the head from the fiber bundle direction. The head mounts to the Model 585-35-13 Fiber Optics Probe with two screws.

3) The Model 585-35-13 Fiber Optics Probe (Figure 43) contains a 1/4-inch diameter, 36-inch long bundle of clad optical fibers enclosed in a PVC jacketed steel armored flex sheath with a teflon liner. The front of the probe contains a square mounting piece with two alignment pins and two through-holes with recessed bores for two Allen head screws. The Allen screw/pin combination attaches to either the Model 585-35-11 or Model 585-35-12 Viewing Heads. The mounting piece has a bearing in the center which allows 180^{O} swivel of either head. The probe has an adapter piece on the other end that allows mating to either the Model 580-32 Hooded Filter Holder or the Model 585-35-14 Probe Input Optics.

Figure 43. Model 585-35-13 Fiber Optics Probe.

4) The Model 585-35-14 Probe Input Optics (Figure 44) connects to the back of the Fiber Optics Probe when the assembly is used with the Spectroradiometer System. The probe input optics bayonets on the entrance of the Model 585-11 Monochromator Housing and ensures that the entrance slit of the monochromator is fully illuminated. The Probe Input Optics replaces the Model 585-31 or 585-32 Beam Input Optics when the Fiber Optics Probe Assembly is used with a Spectroradiometer System. The

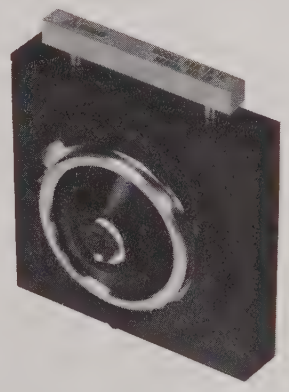


Figure 44. Model 585-35-14 Probe Input Optics.

second function of the Probe Input Optics is that of a filter holder for the Model 585-20-10 Series of order-sorting filters.

When the Fiber Optics Probe Assembly is used with a Radiometer System the detector input diffuser is removed because the diffuser in the Viewing Head takes the place of the input diffuser of the Radiometer System.

3.8.1 Specifications

Spectral Range	0.35 to 1.2 microns
Field of View	$\cos^{1.5}\theta$, were θ = angular deviation from normal axis
Dimensions	1/4" × 36" Fiber Bundle
Minimum Bend Radius	1.5 inches
Minimum Power of Energy as Radiometer	$8.2 \times 10^{-10} \frac{\text{watts}}{\text{cm}^2}$ or $\frac{\text{joules}}{\text{cm}^2}$ with S-10 or S-20 at 5000nm
	$1.7 \times 10^{-9} \frac{\text{watts}}{\text{cm}^2 - \text{nm}}$ or $\frac{\text{joules}}{\text{cm}^2}$ with S-1* at 900 nm
Minimum Power or Energy as Spectroradiometer	$4 \times 10^{-10} \frac{\text{watts}}{\text{cm}^2 - \text{nm}}$ or $\frac{\text{joules}}{\text{cm}^2 - \text{nm}}$ with S-10 or S-20 at 500 nm
	$2.7 \times 10^{-9} \frac{\text{watts}}{\text{cm}^2 - \text{nm}}$ or $\frac{\text{joules}}{\text{cm}^2 - \text{nm}}$ with S-1* at 900 nm

*S-1 denotes Model 585-63 High Sensitivity Detector Head.

3.8.2 Physical Characteristics

Model 585-35-11
- Length: 1-3/4 inches
- Height: 3/4 inch
- Width: 3/4 inch
- Weight: 2 ounces

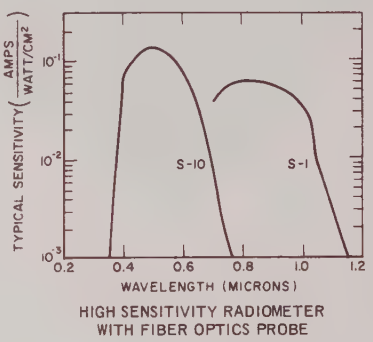
Model 585-35-12
- Length: 1-3/4 inches
- Height: 3/4 inch
- Width: 3/4 inch
- Weight: 2 ounces

Model 585-35-13
- Length: 36 inches
- Height: 1/4 inch

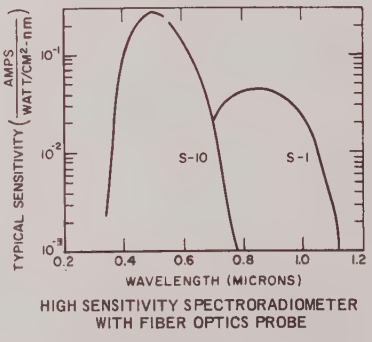
Model 585-35-14
- Length: 2-3/4 inches
- Height: 4-5/8 inches
- Width: 4 inches
- Weight: 1 pound, 6 ounces

3.8.3 Calibration

The Fiber Optics Probe is calibrated as a total system with a Radiometer or Spectroradiometer System. Some typical sensitivity values are shown in Figure 45.



HIGH SENSITIVITY RADIOMETER WITH FIBER OPTICS PROBE



HIGH SENSITIVITY SPECTRORADIOMETER WITH FIBER OPTICS PROBE

Figure 45. Typical Sensitivity Values Using Fiber Optics Probe.

3.9 MODEL 585-36 TELESCOPE (Model 580 Radiometer, Model 580/585 Spectroradiometer)

The Telescope (Figure 46) provides additional capability to both the Model 580 Radiometer and the Model 580/585

Figure 46. Model 585-36 Telescope.

Spectroradiometer Systems. The Telescope permits selection of discrete narrow fields of view of 7-1/2', 15', 30', 1^{o}, and 2^{o}. With this feature, absolute light measurements can be made in terms of both radiance (or luminance) and irradiance (or illuminance). Small and/or distant sources can readily be measured and characterized.

The optical system in the telescope is a reflective, off-axis, paraboloid with an eye viewing system which allows sighting through the telescope. The viewing system, which has an approximate magnification of nine, includes a reticle with cross hairs and concentric circles representing each field of-view field stop. The image presented to the eye is erect. The focal range of the telescope is from 6 feet to infinity and the spectral response is from 0.2 to 3.2 μm.

The optical system can be described as three basic subsystems: (1) the Primary Imaging System; (2) the Viewing System; and (3) the Spectroradiometer Input System. When using the telescope with a Radiometer System an additional mating piece with lens (Model 585-36-11 Radiometer/Telescope Adapter) is used to assure optimum illumination of the detector surface.

The Primary Imaging System (see Figure 47) forms an image of the object to be measured at the field stop. The components of the Primary System are:

1) the quartz window,
2) the aperture stop, 0.850 inch diameter,
3) the 8-inch focal length f/2 parabola,
4) the 45^{o} mirror, and
5) the field stop apertures.

The quartz window serves as a dust cover to seal the instrument. It is made of an IR grade quartz to meet the spectral range specifications. The aperture stop defines the amount of light accepted by the instrument. Since the parabola folds the light back on itself, a 45^{o} mirror is placed in the system to reflect the light to a point where it can be viewed. This folding mirror would normally obscure part of the light from the aperture in an on-axis system. However, since the reflecting objective (parabola) is located off the axis of symmetry and only one side of the mirror is used, this problem is eliminated. The paraboloid objective also eliminates the problem of spherical aberration.

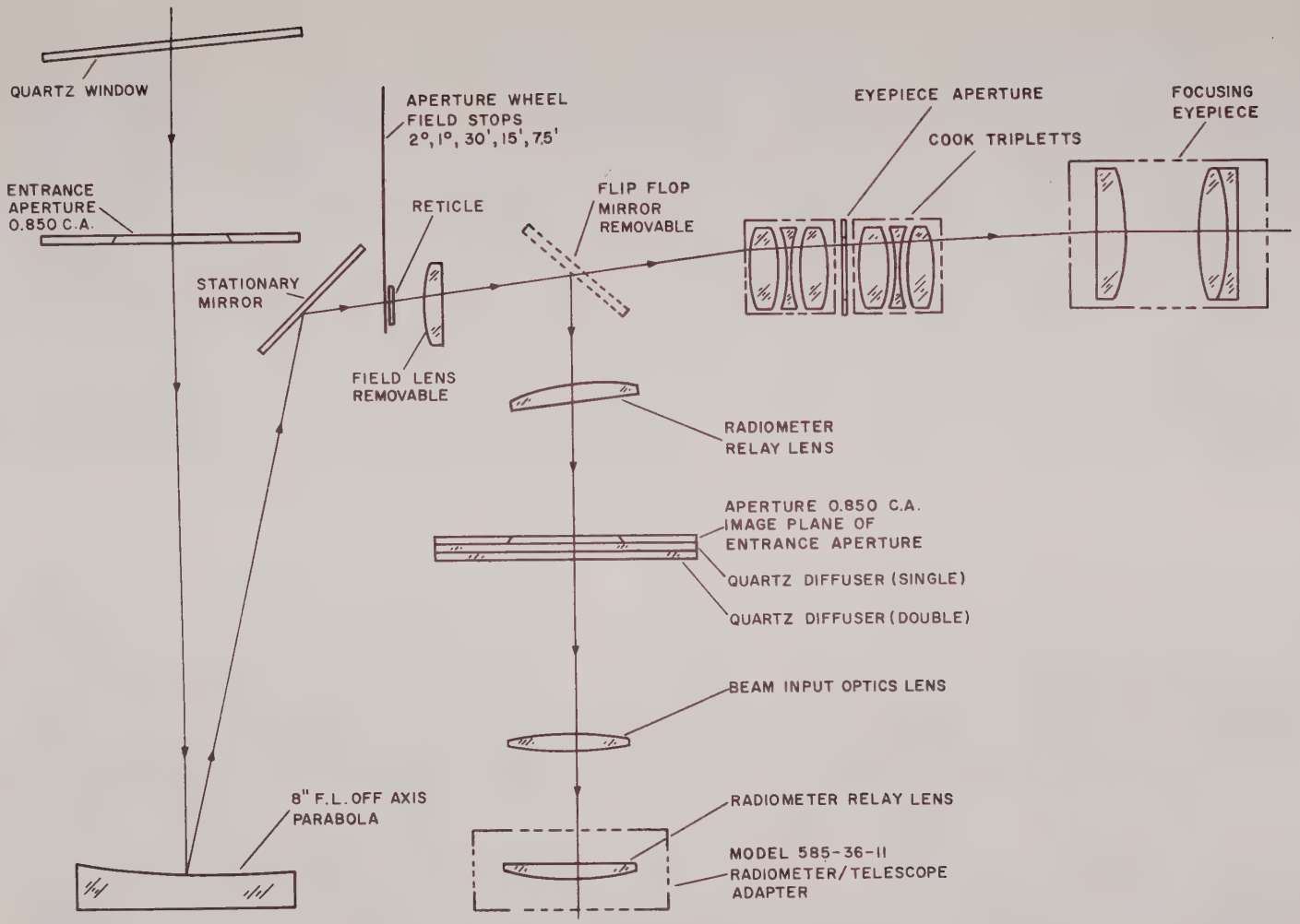


Figure 47. Optical Schematic Model 585-36 Telescope.

Residual coma is minimized in the balancing of the field angle and speed. An 8-inch focal length parabola is used in the system, and its speed is set at f/2 to collect all of the off-axis rays coming from the near conjugate point (six feet). The light from the 45° diagonal mirror is reflected to the field stop wheel located at the focus of the parabola. The field stop wheel contains six precision apertures: 7-1/2', 15', 30', 1°, 2° field stops, and a 2° field stop with a reticle for alignment purposes.

The viewing system consists of the following:

1) two f/3.5 Cooke triplets, 50 mm f.l.,

2) a focusing eye piece, 22 mm f.l., and

3) a field lens.

The Cooke triplets relay the image formed by the parabola at a 1:1 magnification to the eye piece. An image relay system is necessary because the flip-flop mirror used to reflect the light into the spectroradiometer input system prevents an eye piece from being used to directly view the image formed by the parabola. The focusing eye piece is used to bring a clear image of the crosshair, concentric circle reticle to the eye. The centerlines of the parabola, the Cooke triplets, and the eye piece are all parallel to each other but are noncoincident. The field lens, which is located at the field stop, images the aperture stop onto the Cooke triplets. Its focal length is 2 inches. The field lens brings the image closer to being on-axis and improves the image quality. Since the field lens is only used in the viewing system, it is automatically removed from the optical path when measurements are made.

The components of the spectroradiometer input system are

1) a flip-flop mirror,

2) a spectroradiometer relay lens,

3) a quartz diffuser, and

4) a beam input optics lens.

The mirror reflects the light diverging from the image plane onto the quartz relay lens. The parabola forms an image of the apertures stop at infinity. The relay lens forms an image of the (infinity object) aperture stop not the field stop, on the quartz diffuser. The beam input optics lens focuses an image of the illuminated portion of the diffuser onto the monochromator grating.

3.9.1 Specifications

Diameter of Entrance Aperture: 0.850"
Focus Range: 6 feet to infinity
Field of View: 7.5', 15', 30', 1°, and 2° with set field stops
Viewing System: Erect image; Total magnification approximately 9X
Alignment: Reticle with crosshairs and concentric circles same size as field stops
Spectral Range: 0.2 to 3.2 μm
Size: 12" x 10 1/2" (plus 2" for eye piece) x 8 1/4"
Weight: 18 lbs.

3.9.2 Operation

When the telescope is used with a Radiometer Detector Head, the input diffuser of the Detector Head is removed (the 1-aperture position is used with Model 580-20 Series Detector Heads) and the Model 585-36-11 Radiometer/Telescope Adapter mates the Detector Head to the telescope. The Adapter contains a lens which relays the image of the diffuser from the beam input optics lens to the detector. This assures optimum utilization of the detector surface.

The controls on the telescope are as follows:

(1) FUNCTION switch: Two-position: VIEW - DET. In the VIEW position, the object may be sighted through the eye piece. The 45° flip-flop mirror is out of the light path and the field lens is in the light path. In the DET position, the field lens is out and the 45° mirror is in the light path, directing the light to the detection system.

(2) FIELD STOP switch: Changes the aperture stops from Reticle (2°) to 2°, 1°, 30', 15', or 7-1/2' field of view.

(3) Eye Piece: The eye piece has a focus adjustment (turning of eye piece) to bring the image of the crosshairs and concentric circles into sharp focus.

(4) FOCUS control: A multiturn knob that sets the focus of the object from 6 feet at one extreme to infinity at the opposite extreme. Precise focus is not necessary for accurate irradiance (illuminance) readings. Infinity setting (full stop) is used for radiance (luminance) readings.

In operating a Spectroradiometer System with the telescope, the telescope takes the place of the Model 585-30 Series Beam Input Optics.

Alignment of the system is simple and can be accomplished by taking the following steps:

1) Set the switches and controls

Function to VIEW

Field stop to RETICLE

Eye piece focused on crosshairs and concentric circles

Focus control to bring object to be measured into focus.

2) Determine if radiance (luminance) or irradiance (illuminance) measurements are desired.

3) If radiance (luminance) measurements are desired, set for field stop that will be overfilled by the source. This is determined by the concentric circles in the Reticle field stop position and the calculation below. Set to infinity (∞) focus and take measurements in the same manner as conventional Radiometer or Spectroradiometer System.

4) In making irradiance (illuminance) measurements set for field stop position that ensures that the source to be measured does not overfill the field stop. This is also determined by the concentric circles in the Reticle Field stop position. Take readings in the normal manner. Exact focus of the source to be measured is not necessary.

The general definition of radiance measurements calls for a uniform source that overfills the field of view. The minimum object size requirement for radiance measurements is obtained from the following equation:

$$S = 0.850 + 2d \tan \theta/2$$

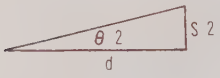
where

S = source size in inches

θ = field of view

d = distance to source

The calculated source size with a 7-1/2' field stop at 6 feet is as follows:



θ = field stop
S = additional source size
d = distance to source
$\tan \theta/2 = \tan 3.75' = 0.00108$
$d = 6 \times 12 = 72$ inches

$\tan \theta/2 = (S/2)/d$
$S = 2d \tan \theta/2$
$S = 144 (0.00108) = 0.158$ inch
$S = S + 0.850 = 0.158 + 0.850$
$= 1.008$ in.

Therefore the minimum source size that would overfill the optics with a 7-1/2' field stop at 6 feet is 0.850 inch plus 0.158 inch or 1.008 inches.

The following table lists the field stop settings and the distance multiplier which yields the appropriate field stop factor. Add 0.850 inch to the field stop factor to get the source size to exactly fill the optics system. ($S = 0.850 + M \cdot d$)

Field Stop	Distance Multiplier (M)
2°	0.0349
1°	0.0175
30'	0.0087
15'	0.0044
7-1'2'	0.0022

For irradiance (illuminance) measurements, a point source can be measured at 6 feet. Alignment may be a problem in making irradiance measurements at distances closer than 6 feet, since it is possible to run off the optical axis of the system.

The maximum object size for irradiance measurements can be calculated as $M \cdot d$ (as above) for objects greater than 100 times the focal length (8 inches) or 800 inches (66.6 feet).

Within 100 times the focal length, the relationship below can be used. The system magnification, when the telescope is focused, is determined from the following equations:

$$1/f = 1/p + 1/q$$

$$m = q/p$$

f = focal length of parabola (8 inches)

p = object distance (inches)

q = image distance (inches)

m = magnification

Solve the first equation for image distance (q), and then solve for m in the second equation. The maximum diameter object for each field stop can then be found from the following equation:

$$D_o = D_{fs}/m$$

D_o = diameter of object (inches)

D_{fs} = diameter of field stop (inches)

m = magnification

Values of D_{fs} are found by multiplying the focal length (8 inches) by 2d tan $\theta/2$ and are:

Field Stop	D_{fs}
2^0	0.280
1^0	0.140
30	0.070
15	0.035
7.5	0.017

The Model 585-36 Telescope can be calibrated with both the Radiometer and Spectroradiometer Systems. As a Radiometer, calibration data can be provided in terms of radiance, irradiance, luminance, and illuminance (photometric detectors only for the second two). As a Spectroradiometer, calibration data can be provided in terms of radiance and irradiance. Since all calibration is on a total system basis, the accuracies (as a percentage of absolute) are the same as those specified for the appropriate Radiometer and Spectroradiometer Systems. The typical minimum measurable radiance and luminance power or energies for the various systems with telescope are shown below:

RADIOMETER	MIN. POWER/ ENERGY**	UNITS
S-5 Photometric	4.2×10^2	Lumens or Lumen-sec. / $ft.^2$-ster.
S-10* @ 500 nm	7×10^{-9}	Watts or Joules / cm^2-ster.
S-20* @ 500 nm	7×10^{-9}	Watts or Joules / cm^2-ster.
S-1* @ 800 nm	1.3×10^{-8}	Watts or Joules / cm^2-ster.

SPECTRO-RADIOMETER	MIN. POWER/ ENERGY***	UNITS
S-10* @ 500 mu	1.0×10^{-9}	Watts or Joules / cm^2-nm-ster.
S-20* @ 500 nm	1.0×10^{-9}	Watts or Joules / cm^2-nm-ster
S-1* @ 900 nm	6×10^{-9}	Watts or Joules / cm^2-nm-ster.

*High Sensitivity Detector Heads.

**Minimum values based on 2^0 field of view – values increase by factor of approximately four for each subsequent decrease in field of view. Thus for 7.5 minute field of view, min. Power/Energy figures should be multiplied by factor of 256.

3.10 MODEL 585-37 TELESCOPE

The Model 585-37 is a 7.5X reflecting telescope with a 15-inch focal length primary mirror and a 2-inch focal length secondary mirror. Both mirrors are parabolic. It can be supplied in either a Gregorian or a Cassegrain configuration.

The Model 585-37 is used in conjunction with the Model 585-36 Telescope to permit very narrow field-of-view (FOV) measurements. The combined system modifies the FOV from 7.5', 15', 30', 1^{o} and 2^{o} to 1', 2', 4', 8' and 16', respectively. However, the Model 585-37 Telescope should not be used for measurements at the 16' position because vignetting within the Model 585-36 Telescope will reduce the signal approximately 35% for targets located near the edge of the field.

The Model 585-37 Telescope has a 3.5-inch diameter entrance aperture, resulting in a signal gain of approximately 10 over the Model 585-36 Telescope.

A 6X rifle scope is mounted on the side of the Model 585-37 Telescope to facilitate target acquisition. Final target alignment should be accomplished using the Model 585-36 viewing system.

The Model 585-37 Telescope cannot be used directly with the Model 585-36 Telescope without making a slight modification to the internal optics within the Model 585-36 Telescope. This modification is required because the image of the aperture stop of the Model 585-37 Telescope does not coincide with the aperture stop of the Model 585-36.

The Model 585-37 Telescope is not a stock item. It is supplied on special request only for particular applications. The Model 585-37 Telescope is particularly suited for the calibration of star simulators where a large collecting aperture and small fields of view are required.

To meet customer specifications, the basic Model 585-37 Telescope can be supplied with different magnification ratios and collecting apertures, where optically feasible. Its physical characteristics are:

Length:	20.3 inches
Diameter:	5.5 inches (8.66 inches with scope)

3.11 MODEL 585-38 SERIES MICROSCOPE

3.11.1 Description

The Model 585-38 Series Microscope is designed as an accessory for use with the Radiometer or Spectroradiometer Systems. It is intended mainly for use with the High-Sensitivity Detector Heads because of the lower levels of light available at the detector surface. The Model 585-38 Series Microscope consists of a series of microscope objectives, a four-objective nosepiece, a draw tube microscope body with coarse and fine focus, verniers, a field stop wheel containing six precision apertures (0.004, 0.008, 0.025, 0.050, 0.100 and 0.150-inch diameters), a 3.8X focusing eyepiece,

and input optics to the measuring system. The Model 585-35-13 Fiber Optics Probe (subsection 3.8 and Figure 43) is used to couple the light into the measurement system. The fiber optics directs the light either to a detector (Radiometer System) or through a lens (Model 585-35-14 Probe Input Optics, subsection 3.8 and Figure 44), focusing the light through a monochromator to a detector surface (Spectroradiometer System).

An X-Y axis positioning mount, Model 585-38-12 (Figure 48), with coarse and fine adjustments, verniers, and a Post Clamp, Model 585-38-13 (Figure 49), are available for ease in positioning and aligning the Microscope. The Microscope Series consists of the following basic assemblies:

1) The Model 585-38-11 Microscope (Figure 48), which consists of the four objective nosepieces, the draw tube microscope body with coarse and fine focus, verniers, the 3.8X focusing eyepiece, the six-position field stop wheel, and the measurement coupling optics.

2) The Model 585-38 Series Microscope Objectives are:

a. 585-38-02 2X objective with a numerical aperture (N.A.) of 0.08 and a working distance of 59 mm.

b. 585-38-10 10X objective with an N.A. of 0.25 and a working distance of 8 mm.

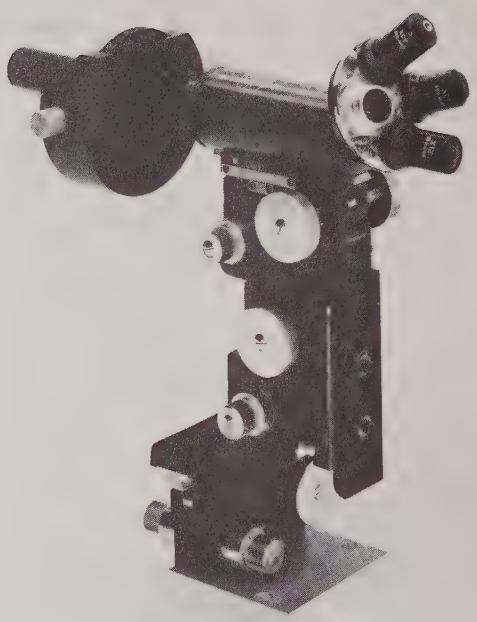


Figure 48. Model 585-38 Series Microscope.

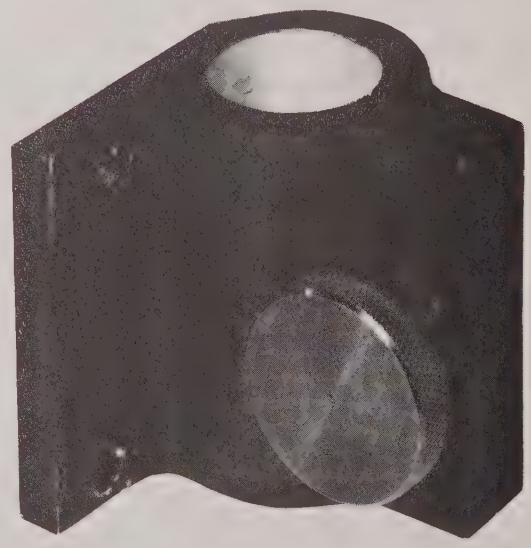


Figure 49. Model 585-38-13 Post Clamp.

c. 585-38-21 21X objective with an N. A. of 0. 50 and a working distance of 1. 7 mm.

d. 585-38-43 43X objective with an N. A. of 0. 65 and a working distance of 0. 7 mm.

e. 585-38-60 60X objective with an N. A. of 0. 85 and a working distance of 0. 2 mm.

f. 585-38-16 telescopic objective with a 160-mm focal length and a maximum field of view of ±40 minutes.

Numerical aperture (Figure 50) is a measure of the resolution and also of the light gathering power of the objective. The higher the N. A. the greater the resolving power of the objective. N. A. is given by the equation

$$N.A. = n \sin \mu$$

where

n = the lowest refractive index that appears between the object and the front lens of the objective,

μ = the half angle subtended by the aperture of the objective from the source as shown below.

The resolution of the objective is given by the equation

$$D = \lambda/(2N.A.)$$

where

D = the least separable distance that can just be detected between two points,

λ = the wavelength of light used.

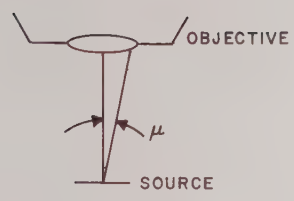


Figure 50. Numerical Aperture.

3) The Model 585-38-12 X-Y axes mounts have a coarse and fine focus and verniers. These mounts attach (with screws) directly to the bottom of the microscope focusing rack.

4) The Model 585-38-13 Post Clamp is a 1. 22-inch (32 mm) diameter clamp used to attach the microscope to the type of microscope stand presently being used by many microscope manufacturers.

3. 11. 2 Operation

If the microscope is used with a Radiometer Detector Head, perform the following steps when setting up the System:

1) Remove the input diffusers from the Detector Head.

2) Attach the 580-32 Hooded Filter Holder, with hood removed, to the Detector Head.

3) Remove the square mounting piece from one end of the Model 585-35-13 Fiber Optics Probe.

4) Attach the Fiber Optics Probe to the Hooded Filter Holder.

5) Insert the other end of the Fiber Optics Probe into the tube at the top of the

microscope and tighten the set screw to lock securely in place.

6) Screw the objectives to be used into the nosepiece.

7) The Model 585-38-12 X-Y axes mount, if it is being used, attaches to the microscope body.

8) The Model 585-38-13 Post Clamp, if it is being used, attaches either to the X-Y axis mount or to the microscope body.

If the microscope is used with a Spectroradiometer System, perform the following steps:

1) Remove the input diffusers from the Detector Head.

2) Attach the Model 585-35-14 Probe Input Optics to the Model 585-11 Monochromator Housing.

3) Remove the square mounting piece from one end of the Model 585-35-13 Fiber Optics Probe.

4) Attach one end of the Fiber Optics Probe to the Probe Input Optics, and insert the other end into the microscope and lock securely in place.

5) Set the objectives to be used into the nosepiece.

When either a Radiometer or Spectroradiometer is operated in conjunction with the microscope, measurements are made as follows:

1) Pull the mirror slide out.

2) Focus the eyepiece on the field stop.

3) Align and focus the microscope on the object to be measured.

4) Select a combination of objective power and field stop diameter such that the object to be measured overfills the field stop.

5) Push the mirror slide back after the system is aligned and focused.

6) To obtain maximum accuracy when making measurements with most of the higher power objectives, the object diameter should be limited to or masked down to about 0.100 inch. If the object diameter is larger than this, scattered light from the microscope objectives may cause the signal to read 3-4% higher than it actually should read. Some care should be exercised when making measurements of out-of-focus objects. Because of the wide angular field of most microscope objectives, the object size required to overfill the field stop will increase rapidly for very small changes in object distance. If measurements are to be made of out-of-focus objects, scan the object using the X-Y axes mounts to see if there is a region of flat response. If there is, center the microscope in this region and make the measurements here.

7) Take measurements in the same manner as when using a conventional Radiometer or Spectroradiometer System.

The general definition of radiance (luminance) measurements calls for a uniform source that overfills the field of view. Table 7 lists the minimum object diameters for the various field stops and objective powers.

The object sizes for the telescope objective are given for an object distance of 10 feet. If working distance and resolution are not the limiting factors, the choice of objective and field stop combination to maximize the sensitivity for a particular measurement can be found as follows. The nominal signal ratios between field stops for any objective and the nominal ratios between objectives at any stop are as given in Table 8.

Table 7. Minimum Object Diameters for Various Field Stops and Objective Powers.

Field Stop Diameter (inches)	Objective Power (inches)					
	2X	10X	21X	43X	60X	Telescope
0.150	0.075	0.015	0.0071	0.0035	0.0025	3.00
0.100	0.050	0.010	0.0048	0.0023	0.0017	2.00
0.050	0.025	0.005	0.0024	0.0012	0.00083	1.00
0.025	0.0125	0.0025	0.0012	0.00058	0.00042	5.00
0.008	0.004	0.0008	0.00038	0.00019	0.00013	0.160
0.004	0.002	0.0004	0.00019	0.000093	0.000067	0.080
Working distance (mm)	59	8	1.7	0.7	0.2	

Table 8. Nominal Signal Ratios Between Field Stops for any Objective and the Nominal Ratios Between Objectives at any Stop.

Field Stop, Signal Ratios		Objective Ratios	
Diameter (inches)	Ratio	Objective Power	Ratio
0.150	1.0	2X	1.0
0.100	0.44	10X	0.42
0.050	0.11	21X	0.36
0.025	0.028	43X	0.15
0.008	0.0027	60X	0.13
0.004	0.0007		

The 2X objective used with the 0.004-inch field stop and the 60X objective used with the 0.150-inch spot could both measure the combination of objective and field stop which would give the most sensitivity when measuring a 0.002-inch spot. The signal from the 60X objective at the 0.150-inch field stop would be a decade less than the 2X for this field stop. The signal from the 2X at the 0.004-inch field stop would be three decades less than the signal from the 2X at the 0.150-inch field stop. Hence, the 60X at the 0.150-inch field stop would have two decades more sensitivity than the 2X at the 0.004-inch field stop position.

3.11.3 Calibration

The Microscope is calibrated as a total system with a Radiometer or Spectroradiometer System. A separate system calibration is necessary for each objective.

3.11.4 Specifications

Spectral Range:	375 to 1100 nm
Magnification:	Viewing - variable up to 248 (eyepiece 3.8X)
	Measurements - variable up to 60X
Measurement Capability:	0.00007 inch (60X objective) to 0.075 inch (2X objective) diameter objects.

The object diameter range telescope objective at 5 feet would be approximately 1.5 inches (0.150-inch field stop) to 0.040 inch (0.004-inch field stop).

Position Adjustments:	Both coarse and fine focus, with verniers, on each of the axes (X, Y, and Z).

Minimum Power or Energy as Radiometer (2X objective - 0.100-inch field stop):

S-10 or S-20 at 500 nm	2×10^{-8} watts or joules/cm^2-ster
S-10 Photometric	1×10^{-6} lumens or lumen-sec/cm^2-ster

Minimum Power or Energy as Spectroradiometer (2X objective - 0.100-inch field stop):

S-10 or S-20 at 500 nm	2×10^{-7} watts or joules/cm^2-nm-ster

3.11.5 Physical Characteristics

Model		
585-38-11	Length:	10-1/2 inches
	Height:	5 inches
	Width:	5 inches
	Weight:	3 lbs, 10 oz
585-38-12	Length:	5 inches
	Height:	6 inches
	Width:	3-1/2 inches
	Weight:	3 lbs, 8 oz
585-38-13	Length:	3 inches
	Height:	3 inches
	Width:	2-3/4 inches
	Weight:	1 lb

3.12 MODEL 580-33 SERIES FIELD-OF-VIEW ADAPTERS

The Model 580-33 Series Narrow Field-of-View Adapters (Figure 51) can be used with all Radiometer and Spectroradiometer Systems to define a sharp field of view. Two standard models are available: the Model 580-33-5 has a 5° field of view, and the Model 580-33-10 has a 10° field of view. In addition to these standard models, the Model 580-33 Series Narrow Field-of-View Adapters (NFOVA) can be supplied with any field of view from 2° to 10°.

The optics in the Model 580-33 Series NFOVA are quartz, so they can be used over the spectral range from 200 to 3200 nm; however, since they are refractive elements and are basically designed to work in the visible, some care should

Figure 51. Model 580-33 Series Narrow Field-of-View Adapters.

be taken if using them in the UV or IR. The objective lens in the Narrow Field-of-View Adapter has an effective focal length of 2.6 inches.

The Narrow Field-of-View Adapter can be used to measure either the irradiance (illuminance) or a radiance (luminance) of a source. To make an irradiance (illuminance) measurement, the image of the source has to be within the field stop. To make a radiance (luminance) measurement, the image of the source should overfill the field stop.

The Narrow Field-of-View Adapters bayonet directly to the Detector Head (Radiometer) or the Beam Input Optics (Spectroradiometer).

The apertures in the 580-20A Series Detector Head will not ratio properly when used in conjunction with the Narrow Field-of-View Adapters because the diffuser is not fully illuminated in this mode of operation.

3.12.1 Physical Characteristics

Length:	5-1/8 inches
Diameter:	3.75 inches
Weight:	1.6 pounds

Alignment of a NFOVA system is relatively simple even though there is no optical viewing system. Alignment is accomplished in the following way.

1) Approximately align the system to the source to be measured using the visual alignment aids on the Detector Heads so as to obtain a signal on the Indicator Unit.

2) If an irradiance (or illuminance) measurement is being made the image of the source must be completely within the field stop. Scan the system across the source to precisely center it in the field stop. The signal output will be constant for small scanning increments when the source is located within the field stop.

3) If a radiance (or luminance) measurement is being made the image of the source must overfill the field stop. Scan the system across the source to precisely center the system on it. The signal output will be constant for small scanning increments when the system is centered on the source.

The minimum object size requirement for radiance (luminance) measurements is obtained from the following:

$$S = 1.0 + 2 d \tan \theta/2$$

where

S = source size in inches

θ = field of view

d = distance to source

The maximum object size for irradiance measurements is also given by the above relationship for objects greater than 100 times the focal length away. For objects within 100 times the focal length the system should scan across the source in order to determine whether or not it is within the field stop.

SECTION 4

OPERATING INSTRUCTIONS

4.1 MODEL 580 RADIOMETER SYSTEM OPERATION

4.1.1 General

The Model 580 Radiometer System uses simplified techniques for measuring pulsed- and steady-light sources. The simplified procedures and inherently stable optical and electronic elements of the Model 580 enable consistent repetitive measurements to be taken. The following paragraphs explain the procedure for measuring steady light, a light pulse, or a train of light pulses with the system. The method of using the Radiometer for oscilloscope display of pulsed-light waveshapes is also included.

4.1.2 Basic Operating Setup

The following steps comprise the basic setup procedure for the Model 580 Radiometer:

1) Connect a Model 580-11A or 580-12 Indicator Unit cable to a 580-20A Series Detector Head. Spectral region of interest dictates specific Detector Head as indicated in Table 2 and in Figure 8.

CAUTION

Check that the Detector Head input diffuser disc (or discs) have been reinstalled if the Head was previously used in the Spectroradiometer System.

2) If a photometric filter is desired for light measurement, connect it to the Detector Head (see subsection 3.6).

3) Connect the Model 580-32 Hooded Filter Holder to the Detector Head.

4) Check mechanical zero on the Measurement Indicating Meter (Figure 10).

5) Connect the Indicator Unit power cable to the external 117V, 60-Hz (220V, 50-Hz) line if battery operation is not desired. Place the POWER switch (Indicator Unit) to appropriate position. Allow a two-minute warmup time to stabilize all circuits.

4.1.3 Detector Head Positioning

The sighting aids incorporated in the Model 580-20A Series Detector Heads provide a simple positioning method for the Detector Head and light source. Sight alignment accuracy with the light source is

better than one degree when using the "centerline" guide markings on the handle and on each side of the Detector Head. The field-of-view guide markings on the handle show that the light source under evaluation is fully seen by the Detector Head. Because the viewing hood and diffuser disc function to make alignment noncritical, the accuracy of a careful visual positioning is sufficient for reliable light measurements with the instrument.

The Detector Head-to-light source distance is measured from the plane of the diffuser disc. This plane coincides with the front surface of the Detector Head. The Detector Head-to-light source distance will vary with the types of measurements, source power, and geometry. For absolute radiometric or photometric measurements, the "minimum-inverse-square distance" should be used. This is generally approximated by use of a minimum distance ten times that of the largest source dimension. Final positioning of the Detector Head then requires only that the light source be aligned as follows:

1) Centered and fully included in the Detector Head field of view.

2) At a known distance greater than minimum-inverse-square distance for absolute measurements, or consistently reproducible for relative measurements.

4.1.4 Premeasurement Adjustments - Current Mode

Set Indicator Unit controls as given in Table 9. Position the Model 580-20A Series Detector Head in approximate final alignment for light measurement. Indicator Unit controls should remain in the positions specified in Table 9. Place the Detector Head controls to the positions specified in Table 10.

Table 9. Indicator Unit Control Settings

Control	Position	Remarks/Action
POWER switch	LINE or BATTERY (Operator's choice)	Pilot lamp blinks.
(COMPENSATION) "Function" switch	OFF CURRENT	- -
AMPERE MULTIPLIER switch	X10-6	-
INTEGRATE switch	HOLD	*
ZERO SET potentiometer	-	Adjust control for a meter indication of zero using X 3 MULT to exaggerate zero offset (see Note).
CURRENT DAMPING potentiometer	Full CCW	-
*After adjustment of ZERO SET, return INTEGRATE switch to RESET position.		

Table 10. Detector Head Control Settings

Control	Position	Remarks/Action
NEG BIAS VOLTAGE switch	INT	Detector Head is energized by Indicator Unit.
EXTERNAL VIEWING MULTIPLIER switch	Optional	(Used for external instrument readout only.)
ANODE switch	INT	Enables Indicator Unit to monitor output current.
APERTURE MULTIPLIER switch	1	(Or lowest position for on-scale meter reading.)
SIGNAL switch	ANODE	Signal output from anode of photodiode.

NOTE

Press the X3 MULTIPLIER and the zero meter with the ZERO SET control. With alternate depressing of the X3 MULTIPLIER, meter should be set as to have no movement when depression is made. This nonmovement point should be the zero line of the meter; if this is not the case, mechanical zero of the meter is off. Simply turn off power and adjust meter zero screw (front of meter) with a screwdriver. Turn on power again and repeat foregoing procedure. Indicator Unit internal circuitry is now balanced at a zero point.

If using the Model 580-12 Indicator Unit, adjust the control to set all digits equal to zero.

For preliminary adjustment of the Radiometer System prior to actual current measurements, perform the following steps:

1) Position the Detector Head to accept approximately the same ambient light as will be viewed during actual measurement.

2) Establish scale of measurement by momentarily energizing the light source. Note the ambient current reading on this scale.

3) Select proper COMPENSATION RANGE position (Indicator Unit) to zero meter reading.

4) Adjust the COMPENSATION VERNIER control for zero meter reading on this setting of the AMPERE MULTIPLIER switch.

NOTE

Ambient light conditions can vary and proper compensation should be verified for careful measurements. Always recheck after changing the Detector Head aperture position. (See also special notes on apertures in subsequent subsection.)

4.1.5 Measurement Procedures - Current Mode

For final measurement of average power of steady-light sources, utilizing meter readout, proceed as follows:

1) Align the Detector Head as already described.

2) Set controls on the Indicator Unit for CURRENT measurement.

3) Energize the light source.

4) Adjust the APERTURE MULTIPLIER and AMPERE MULTIPLIER settings, as necessary, to obtain maximum meter indication. Do not exceed a reading of 16.00 on the Digital Indicator for proper linear operation.

5) Record the final meter reading and settings of the AMPERE MULTIPLIER and the APERTURE MULTIPLIER switches. Final current in amperes is proportional to irradiance viewed by the Detector Head.

NOTE

A sample calculation of measurement of average power of a steady-light source is supplied at the end of this Radiometer System operating subsection.

4.1.6 Premeasurement Adjustments - Charge Mode

For preliminary adjustment of the Radiometer System prior to actual charge measurements, perform the following steps:

1) Position the Detector Head to accept approximately the same ambient light as will be viewed during actual measurement.

2) Repeat Table 9 control settings.

3) Set "Function" switch for charge measurement. Select the scale of measurement by pulsing the light source to be measured.

4) Place INTEGRATE switch from (normal) RESET to INTEGRATE position. Meter will indicate amount of integrated ambient light.

5) Select the appropriate position of the COMPENSATION RANGE switch to minimize rate of meter movement.

6) Adjust the COMPENSATION VERNIER potentiometer, if necessary, to hold a constant meter reading.

4.1.7 Measurement Procedure - Charge Mode

For final measurement of integrated energy of pulsed light sources, utilizing meter readout, proceed as follows:

1) Align the Detector Head as already described.

2) Set controls on the Indicator Unit for CHARGE measurement.

3) Adjust the ZERO SET control only in CURRENT side, as described in Table 9. Adjust the COMPENSATION control to stop up-scale movement in the INTEGRATE position. If the light source cannot be triggered or scheduled, the INTEGRATE switch must be advanced to INTEGRATE prior to commencement of the light pulse. (Move the switch to the HOLD position when the light pulse has ceased.)

NOTE

Proper measurement of a random light source (event) requires operating familiarity.

4) Adjust the APERTURE MULTIPLIER and the COULOMB MULTIPLIER for maximum meter indication through successive measurements. Record the final meter indication and settings of the COULOMB MULTIPLIER and APERTURE

MULTIPLIER switches. Final meter indication in coulombs is proportional to total integrated energy in pulse as viewed by the Detector Head.

5) If the light source can be triggered, the appropriate SYNC contacts, N. O. or N. C., are used to trigger it. Using this procedure, light source is initiated by advancing the INTEGRATE switch from RESET through INTEGRATE position to the HOLD position in a firm, fluid movement. Terminal jacks are provided for the synchronization signal connection. Adjust the APERTURE MULTIPLIER and COULOMB MULTIPLIER for maximum meter reading through successive measurements. Record final meter indication and settings of COULOMB MULTIPLIER and APERTURE MULTIPLIER switches. Do not exceed a reading of 16. 00 on the Digital Indicator for proper linear operation.

6) Single-pulse measurement procedures also apply to a burst (short) of pulses. Bursts can be measured as random events or synchronized events triggered by the INTEGRATE switch. Measurement in this case represents total value of integrated irradiant energy in burst as viewed by the Detector Head. Any ambient light or leakage that is not balanced out will cause an error in readings; see subsection 2. 2. 3(8).

4. 1. 8 External Measurements

Measurement capabilities of the Model 580-20A Series Detector Heads provide for oscilloscope display of repetitive and transient voltage or current signals. For oscilloscope viewing, the SIGNAL connector on the Detector Head is connected by a coaxial cable to the vertical amplifier of a suitable fast-rise, wide-band oscilloscope.

With the ANODE switch in the EXT position, voltage proportional to the light event seen by the Detector Head is displayed on the oscilloscope. The position of the EXTERNAL VIEWING MULTIPLIER switch provides three levels of signal amplitude. If it is desired to use the Indicator Unit simultaneously with the oscilloscope, set the SIGNAL switch to CATHODE and the ANODE switch to INT. For oscilloscope viewing, an Indicator Unit or an external power supply can be used to bias the Detector Head.

CAUTION

Do not apply more than 150V to the bias when using the Indicator Unit. There is also a 150-mA current capability limit on the Indicator Unit power supply. If this limit is exceeded, error and distortion will be introduced by flattening of the pulse and elimination of the peak. If in doubt, calculate the current by dividing the pulse width into the charge in coulombs. If the value exceeds 150 mA, use the aperture to attenuate it.

The INTEGRATE switch and SYNC contacts can be used to initiate a pulsed-light event.

Voltage measurements and pulse-shape characteristics are made directly from the oscilloscope trace.

4.1.9 Apertures When Using Oscilloscope

The Model 580-20A Series Detector Heads are set up with a variable-aperture wheel that allows the full photodiode to look at various portions of the input diffuser, from full diffuser to 1/3000 of the diffuser (explained in subsection 2.5.2, Optics).

When using the Model 580-20A Series Detector Heads with an oscilloscope, the trimming potentiometers are not in effect and the apertures have their normal mechanical ratios. With a simple technique, it is possible to determine the mechanical error in the apertures to make more accurate readings with an oscilloscope. The step procedure is as follows:

1) Connect the Model 580-20A Series Detector Head to the Model 580-11A or 580-12 Indicator Unit.

2) Set the Indicator Unit controls as follows: RANGE COMPENSATION to OFF; INTEGRATE to HOLD; AMPERE MULTIPLIER to X 10^{-6}; CURRENT-CHARGE to CURRENT; POWER to LINE or BATTERY.

3) Zero unit, also using X3 MULTIPLIER to exaggerate zero offset. If using the Model 580-12 Indicator Unit, set all digits equal to zero to check meter zero.

4) Set Detector Head controls as follows: ANODE to INT; NEG BIAS VOLTAGE to INT; SIGNAL to ANODE; APERTURE MULTIPLIER to 1.

5) Switch Indicator Unit controls as follows: CURRENT-CHARGE to CHARGE; COULOMB MULTIPLIER to X 10^{-8}; INTEGRATE to RESET.

6) The meter should be reading less than 1 on scale. If not, reduce amount of light that the Detector is seeing by simply aiming or partially covering the Detector Head.

7) Put the INTEGRATE switch in the INTEGRATE position and allow meter to travel to approximately 8 on the scale before pushing the INTEGRATE switch into HOLD.

8) Copy down the value given on the meter. Switch down through aperture positions 3, 10, 30, etc., and copy down values given on the meter for each aperture position while the INTEGRATE switch is kept in the HOLD position. Deviations in the meter readings are electrical corrections that were made at summing junction of the Indicator Unit by the trim potentiometers.

9) Take 1-aperture position value and find the difference reading (plus or minus) from each of the aperture positions. Percent mechanical difference is 1-aperture reading divided into the difference between

1-aperture reading and any other aperture reading times 100. That is

$$\% \text{ Error} = \frac{(R_{1ap} - R_{xap})\ 100}{R_{1ap}}$$

Example:

The 1-aperture charge reading is 8.02×10^{-8} coulombs

The 10-aperture charge reading is 7.49×10^{-8} coulombs

$$\% \text{ Error} = \frac{(8.02 - 7.49)\ 100}{8.02} = 6.6\%$$

TYPICAL EXAMPLE, RADIOMETER MEASUREMENT

What is the average power of a light source whose output at 500 nm gives a meter reading of 4.0×10^{-7} ampere (A)? System sensitivity at 500 nm is 1.2×10^{-2} A/W/cm^2. Wavelength of source 500 nm is set by narrow-bandpass filter whose transmission at 500 nm is 85%. Aperture multiplier is set at 10-position. Source output is calculated as follows:

$$E_e = \frac{4.0 \times 10^{-7} \times 10}{1.2 \times 10^{-2} \times 0.85}$$

$$= 3.92 \times 10^{-4} \text{ W/cm}^2$$

4.2 MODEL 580/585 SPECTRORADIOMETER OPERATION

4.2.1 General

The following instructions explain the operational procedures necessary for proper operation of the Model 580/585 Spectroradiometer System when using the Model 580-20A Series Detector Heads.

NOTE

The apertures discussed above are not used in measurements with the Spectroradiometer System because the beam from the Monochromator is small and the diffuser is not used. The beam falls directly onto the photodiode surface. The apertures could do nothing more than eliminate an undetermined amount of light.

4.2.2 Basic Operating Setup

Before using the Spectroradiometer System, select the proper components for the spectral region to be measured. The following step-by-step procedure should be followed to obtain satisfactory operating results:

1) Select the Model 585-20-10 Series Filter for the range to be measured and install it in the Model 580-32 Hooded Filter Holder (see Table 6). The hood portion of the holder may be removed.

2) Connect the Filter Holder portion to the appropriate Model 585-32 Beam Input Optics (see subsection 2.11).

3) Before attaching the Beam Input Optics to the Monochromator Housing, select and attach the appropriate Model 585-20-20 Series Fixed or Variable Slits, determined by the amount of dispersion desired in output beam (see Table 5 and subsections 2.14 and 3.4). If it is

desirable to use Variable Slits, proper ratios and openings must be set.

NOTE

Spectroradiometer Systems are calibrated at the factory using Model 585-20-22 Fixed Slits (entrance width of 2.68 mm and exit width of 1.50 mm) for both visible and IR ranges. For UV range, Model 585-20-21 Fixed Slits (entrance width of 5.36 mm and exit width of 3.00 mm) are used. These are the standard grating-slit combinations, unless otherwise specified in ordering a system. If other slits are used, calibration accuracy must be ascertained prior to use (Section 5). Bandwidth is not considered in the calculation of output, but is required in determining the steps necessary to fully evaluate a source.

4) Install the appropriate Model 585-20 Series Grating into the Monochromator Housing. Grating selects spectral range to be presented to the photodiode in the Detector Head (subsection 2.13). Adjust the grating control for the proper wavelength.

CAUTION

The diffuser disc(s) of a Model 580-20A Series Detector Head must always be removed before attaching the Detector Head to the Monochromator Housing. A tool is provided for removal of the glass retaining ring.

5) Connect the Detector Head (see also Figure 6) to the Monochromator Housing. Set the APERTURE MULTIPLIER switch to the 1 position. Set controls as indicated in Table 10.

6) Attach all components to the Model 585-00-11 or 585-00-12 Adapter.

7) Connect the Model 580-11A or 580-12 Indicator Unit cable to the Detector Head. Set controls as indicated in Table 9.

8) If desired, the Model 585-11-11 Wavelength Transducer can be attached to the top of the grating (see subsection 4.6) to give a 0- to 10-mV output from beginning to end of the wavelength dial.

4.2.3 System Alignment

To be measured the light source must be set up with a $\pm 2.5^{o}$ cone working from the center of the first diffuser in the Beam Input Optics. The normal rule (for getting absolute readings) of keeping the distance from this diffuser to the source ten times the maximum source diameter also applies to have the source appear as a point. The first diffuser at the Beam Input Optics is always the System reference point.

4.2.4 Measurement Procedure -Current Mode

For the final measurement of the average power of steady-light sources,

utilizing the meter readout, proceed as follows:

1) Align the Spectroradiometer as already described.

2) Set the controls on the Indicator Unit for CURRENT measurement.

3) Set the Monochromator to the desired wavelength.

4) Energize the light source.

5) Insert the proper order sorting filter.

6) Adjust the AMPERE MULTIPLIER settings, as necessary, to obtain the maximum meter indication. Block light source and recheck ambient compensation. Do not exceed a reading of 16.00 on the Digital Indicator for proper linear operation.

7) Unblock the light source.

8) Record the final meter reading and the setting of the AMPERE MULTIPLIER switches. Final current in amperes is proportional to the irradiance viewed by the Detector Head.

TYPICAL EXAMPLE, SPECTRORADIOMETER MEASUREMENT

What is the average power of a light source whose output at 500 nm gives a meter reading of 4.0×10^{-7} amp(A)? System sensitivity at 500 nm is 1.0×10^{-2} A/W/cm^2-nm (APERTURE MULTIPLIER is set on No. 1 position;* wavelength is set on grating at 500 nm). Source output is calculated as follows:

$$E_e = \frac{4.0 \times 10^{-7}}{1.0 \times 10^{-2}} = 4.0 \times 10^{-5} \text{W/cm}^2 \text{-nm}$$

*Aperture setting is always at No. 1 position in all Spectroradiometer System measurements.

4.2.5 Measurement Procedure - Charge Mode

For final measurement of integrated energy of pulsed-light sources, utilizing meter readout, proceed as follows:

1) Align the Spectroradiometer as already described.

2) Set the controls on the Indicator Unit for CHARGE measurement.

3) Set the Monochromator to the desired wavelength.

4) Insert the proper order sorting filter.

5) Adjust the ZERO SET control only in the CURRENT mode, as described in Table 9. Adjust the COMPENSATION control to stop the up-scale movement in the INTEGRATE position. If the light source cannot be triggered or scheduled, the INTEGRATE switch must be advanced to INTEGRATE prior to commencement of the light pulse. (Move the switch to the HOLD position when the light pulse has ceased.)

NOTE

Proper measurement of a random light source (event) requires operating familiarity.

6) Adjust the COULOMB MULTIPLIER for maximum meter indication and setting of the COULOMB MULTIPLIER switch. Final meter indication in coulombs is proportional to total integrated irradiance energy in pulse as viewed by the Detector Head. Do not exceed a reading of 16.00 on the Digital Indicator for proper linear operation.

7) If the light source can be triggered, the appropriate SYNC contacts, N.O. or N.C., are used to trigger it. Using this procedure, the light source is initiated by advancing the INTEGRATE switch from RESET through the INTEGRATE position to the HOLD position in a firm, fluid movement. Terminal jacks are provided for the synchronization signal connection. Through successive measurements, adjust the COULOMB MULTIPLIER for maximum meter reading. Record the final meter indication and settings of the COULOMB MULTIPLIER switch.

8) Single-pulse measurement procedures also apply to a burst of pulses. Bursts can be measured as random events or synchronized events triggered by the INTEGRATE switch. Measurement in this case represents total value of integrated irradiant energy in burst as viewed by the Detector Head. Any ambient or leakage that is not balanced out will cause an error in readings. (See subsection 2.2.3(8).)

4.2.6 Measurement Procedure - External Viewing

Measurement capabilities of the Model 580-20A Series Detector Heads provide for oscilloscope display of repetitive and transient voltage or current signals. For oscilloscope viewing, the SIGNAL connector on the Detector Head is connected by a coaxial cable to the vertical amplifier of a suitable fast-rise, wide-band oscilloscope. With the ANODE switch in the EXT position, voltage proportional to the light event seen by the Detector Head is displayed on the oscilloscope. The position of the EXTERNAL VIEWING MULTIPLIER switch provides three levels of signal amplitude. If it is desired to use the Indicator Unit simultaneously with the oscilloscope, set the SIGNAL switch to CATHODE and the ANODE switch to INT. For oscilloscope viewing, the Model 580-11A or 580-12 Indicator Unit or an external power supply can be used to bias the Detector Head.

CAUTION

Do not apply more than 150V to the bias when using the Indicator Unit. There is also a 150-mA current capability limit on the Indicator Unit power supply. If this limit is exceeded, error and distortion will be introduced by flattening of the pulse and elimination of the peak. If in doubt, calculate the current by dividing the pulse width into the charge in coulombs. If the value exceeds 150 mA, use inverse square law or N.D. filters.

The INTEGRATE switch and SYNC contacts can be used to initiate a pulsed-light event. Voltage measurements and pulse-shape characteristics are made directly from the oscilloscope trace.

4.3 MODEL 580/585 SPECTRORADIOMETER SYSTEM (Model 585-60 Series High-Sensitivity Detector Heads, Figures 52 and 53)

4.3.1 General

Operation of a Model 580/585 Spectroradiometer System using a Model 585-60 Series Detector Head is generally similar to operation using a Model 580-20A Series Detector Head. For a complete understanding of the Model 585-60 Series operation, the entire operating procedure is detailed here. (The procedure is general enough to apply to use of these detectors as either radiometers or spectroradiometers.)

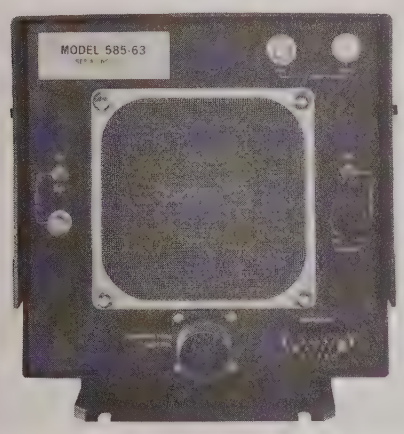


Figure 52. Model 585-63 Detector Head (Showing Controls).

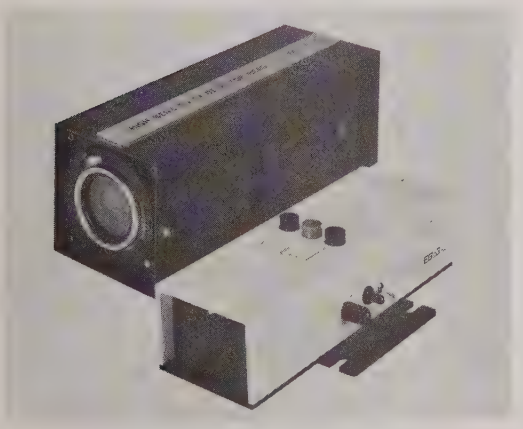


Figure 53. Model 585-66 Detector Head (Uncoupled from Power Supply).

4.3.2 Basic Operating Setup

1) Refer to Figure 3 or Figure 4, depending on whether a Model 585-62, 585-63, 585-64, or 585-66 Detector Head is to be used in the setup. Then, referring to subsection 2.6 as necessary, connect up pertinent Detector Head/Power Supply/Controller combination. Orient the Power Supply (Model 585-62, 585-64, or 585-66 configuration) for left-to-right or right-to-left operation as required. (The two outside receptacles on the Power Supply are common to allow it to be connected in either direction.) In either configuration, Power Supply is locked to its mating component with slide clip fasteners.

2) Select and install appropriate entrance and exit slits on the Model 585-11 Monochromator Housing. (See subsections 2.12, 2.13, and 2.14.)

3) Bayonet-couple the Detector Head (and Power Supply if Model 585-62, 585-64, or 585-66 is used) to the Model 585-11 Monochromator Housing.

4) Insert into the Monochromator Housing the proper grating for the spectral region of interest.

NOTE

Specific model numbers of Detector Heads, Monochromator Gratings, Beam Input Optics, etc., are determined by spectral region of interest. (See subsections 2.11, 2.12, 2.13, Table 1, and Figure 7.)

5) Attach the Monochromator, Detector Head (and Power Supply, if Model 585-62, 585-64, or 585-66 is used) to Model 585-00-11 or 585-00-12 Adapter.

6) Bayonet the Model 585-32 Beam Input Optics to the front end of the Monochromator Housing.

7) Attach the Model 580-32 Hooded Filter Holder in front of the Beam Input Optics and insert the proper Model 585-20-10 Series Filter (Table 6) into the Holder.

8) Connect the Indicator Signal cable to the 14-pin connector at the rear of the Detector Head.

9) If used, connect the Controller cable to the 10-pin connector at the rear of the Detector Head (585-63 only). Similarly, if used, connect both coaxial cables from the Controller to the Detector Head (585-63 only) observing the correct polarity.

10) Set the power switches to OFF on both Power Supply and Indicator Unit and plug in the line cables.

11) Set the controls as indicated in Table 11. The controls are to be operated for each of the three basic measurements, these consisting of steady-light source, pulsed-light source, and oscilloscope display of peak power, pulse width, and pulse shape.

NOTE

The first procedure which follows describes adjustment of the internal lamp gain.

Table 11. Control Settings

Control	Position
INDICATOR UNIT	
AMPERE MULTIPLIER	X 10^{-6}
COULOMB MULTIPLIER	X 10^{-7} or X 10^{-8}
CURRENT – CHARGE	CURRENT
COMPENSATION	OFF (VERNIER CCW)
INTEGRATE Switch	HOLD
CURRENT DAMPING	CCW
POWER	LINE or BATTERY
DETECTOR HEAD	
Shutter (see note below)	Closed
CALIB Switch	OFF
CALIB ADJUST	Mid-Range Mark
SIGNAL	INT
POWER SUPPLY	
VOLTAGE	MIN (Full CCW)
POWER	OFF

NOTE

The Detector Head shutter can be opened by lifting the chrome plunger located in front of the carrying handle. Depressing the red button on the face of the Detector Head closes shutter (Figure 54).

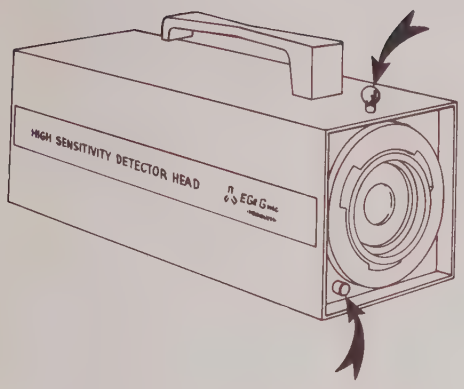


Figure 54. Shutter Controls.

12) Wait one minute, press the X3 MULTIPLIER (if applicable), and zero meter with ZERO SET control. With alternate depressing of the X3 MULTIPLIER, meter should be set as to have no movement when depression is made. This non-movement point should be the zero line of the meter; if this is not the case, mechanical zero of meter is off. Simply turn off power and adjust the meter zero screw (front of meter) with a screwdriver. Repeat from step 11 on. Indicator Unit internal circuitry is now balanced at a zero point. If using the Model 580-12 Indicator Unit, adjust the control such that all digits are equal to zero.

13) Set the Power Supply POWER switch to ON.

NOTE

In the situation where the Model 585-63 High-Sensitivity Detector Head is cooled, the Model 585-00-63 Controller should be turned on one hour prior to taking measurements to allow for stabilization of the cooling cycle.

4.3.3 Internal Gain Adjustment and Compensation Procedures

After a two-minute warm-up, place the Detector Head CALIB switch ON. Place the Indicator Unit AMPERE MULTIPLIER switch to X 10^{-7} and the INTEGRATE switch to RESET.

Set the VOLTAGE control on the Power Supply to give a reading of 10 x 10^{-7} scale on the Indicator Unit. It might be convenient to make any fine adjustments of this voltage by using the ADJUST knob under the CALIB switch on the Detector Head. This now sets the gain of the photomultiplier to the same value as it was when the System was calibrated. On a Model 585-64 Detector Head the VOLTAGE control on the Power Supply should be set to give a reading of 10 x 10^{-10} amperes.

Turn off the CALIB switch. Switch the Indicator Unit AMPERE MULTIPLIER switch down through the scales until there is a reading on the meter. This reading of leakage, which is approximately three decades lower than the calibration (gain) setting, will obviously have no measurable effect on this setting. Therefore, it can be considered as part of the ambient light condition.

The next step is to balance out the combined leakage and ambient light on the scale on which measurements are to be taken. There are notes of CAUTION to be observed at this point. When using the Detector as a Radiometer for broadband light or laser measurements, the level of light the Detector is subjected to should not be high enough to saturate the photomultiplier. Therefore, before the shutter is opened, the ambient level should be decreased to a value somewhere near the source to be measured. When the Spectroradiometer configuration is used, the problem is not as critical since there is only one wavelength of light available to the photomultiplier; however, the ambient level should be lowered. The Radiometer System is compensated by opening the shutter with the Indicator Unit on X 10^{-6} scale and the source to be measured turned off. Then find the scale on which a reading is present and put the COMPENSATION on LOW (switch to MED or HIGH if necessary) and turn the VERNIER control until there is a zero reading on the meter.

In the case of a pulse source (CHARGE switch position), a final check of the compensation is made in the INTEGRATE position. The needle movement is stopped in the INTEGRATE position by the COMPENSATION VERNIER; then the INTEGRATE switch is moved into RESET, then back into INTEGRATE, where there should be no needle movement. Readjust if necessary.

When measurements are made with a Spectroradiometer, the amount of ambient light will change with wavelength. If there is a reading of ambient light on the scale where the source is measured, then the ambient must be balanced at each wavelength. If the reading is only the leakage of the photomultiplier, this value can be balanced out at any wavelength and checked occasionally.

The ambient light and photomultiplier leakage are balanced out, and the source is now measured in the conventional manner with the shutter open.

NOTE

The gain adjustment procedure should be repeated at 15-minute intervals to ensure the highest degree of accuracy in precision light measurements. When setting the gain point, it is helpful to consider the VOLTAGE and CALIB ADJUST controls as coarse and fine controls, respectively.

CAUTION

Turn the ambient COMPENSATION controls OFF before adjustment.

4.3.4 Measuring Spectral Irradiance of Steady Source

After the basic operating setup and internal gain adjustments, the Model 580/585 Spectroradiometer System is ready to perform precision light measurements. The following steps outline the procedure for measuring the average spectral irradiance of a steady light or a continuous train of uniform pulses. Set the controls as stated in Table 12, and perform the following steps:

Table 12. Control Settings

Control	Position
INDICATOR UNIT	
AMPERE MULTIPLIER	X 10^{-6}
COULOMB MULTIPLIER	X 10^{-7}
CURRENT – CHARGE	CURRENT
COMPENSATION	OFF
INTEGRATE Switch	RESET
CURRENT DAMPING	CCW*
POWER	LINE
DETECTOR HEAD	
Shutter	Closed
CALIB Switch	OFF
CALIB ADJUST	As Required
SIGNAL	INT
POWER SUPPLY	
VOLTAGE	As Required
POWER	ON

*Readjust if source is unsteady, or if measuring average value of a pulsing source.

1) Set the Monochromator to the desired wavelength. Install the proper order sorting filter. Open the Detector Head shutter and increase the Indicator Unit sensitivity until a meter indication is obtained (i.e., adjust AMPERE MULTIPLIER to 10^{-7}, 10^{-8}, etc.). Block the light source to be measured without disturbing other ambient light conditions.

2) Using the RANGE and VERNIER controls of COMPENSATION on the Indicator Unit, adjust for a meter indication of zero. Unblock the light source to be measured and record meter indication. (With ambient conditions compensated, it may be necessary to increase Indicator Unit sensitivity to ensure sufficient upscale meter indication.)

TYPICAL EXAMPLE

What is the average power of a light source whose output at 800 nm gives a meter reading of 4.3×10^{-6} ampere (A)? System sensitivity at 800 nm is 25 A/W/cm^2-nm. Each System is provided with a calibration curve of sensitivity vs wavelength.

I_m = current measured on meter (A)

R_λ = System sensitivity at wavelength λ in A/W/cm^2 - nm

$$E_{800} = \frac{I_m}{R_{800}} = \frac{4.3 \times 10^{-6}\ A}{25\ A/W/cm^2\text{-nm}}$$

$$= 1.72 \times 10^{-7}\ W/cm^2\text{-nm}$$

3) Recorded meter indication is current being generated by the photomultiplier due to light source to be measured. This number divided by the system sensitivity at wavelength of the Monochromator setting (system calibration data) is average spectral irradiant power. Repeat measurement at each wavelength of interest and repeat compensation.

4.3.5 Measuring Integrated Spectral Irradiant Energy of Pulsed Source

Following the basic operating setup and internal gain adjustment, the Model 580/585 Spectroradiometer System is ready to perform precision light measurements. The following steps outline the procedure for measuring the integrated spectral irradiant energy of a pulsed light source. Set controls as stated in Table 12, except place CURRENT-CHARGE on CHARGE.

1) Set the Monochromator to the desired wavelength. Open the Detector Head shutter and check that the INTEGRATE switch is in the RESET position.

2) Adjust the RANGE and VERNIER controls of COMPENSATION so that the meter is on zero. Set the INTEGRATE switch to the INTEGRATE position and use COMPENSATION controls to stop meter needle drift. (This need not be an indication of zero, but rather no movement of meter needle; see also foregoing Gain Adjustment and Compensation Procedure subsection.) Return the INTEGRATE switch to the RESET position. Repeat the procedure, if necessary, so that the meter indication stays at zero with no drift. Leave the switch in the RESET position.

3) Connect the sync input of the flash source to N. O. or N. C. SYNC contacts on the Indicator Unit, as required. (Omit this step for nontriggerable flash sources.)

4) Trigger the flash-event by moving the INTEGRATE switch smoothly from the RESET through INTEGRATE and into the HOLD position. For accurate, precise, repeatable readings, it is necessary that the INTEGRATE switch be operated smoothly. If the source cannot be triggered, place the switch at INTEGRATE prior to pulsing the source, then into HOLD after the pulsed event.

NOTE

The time it takes to say "RESET/INTEGRATE/HOLD" is a handy rule of thumb to indicate speed with which the switch should be operated through its respective positions. Do not "flick" switch from position to position, as this will give rise to inaccurate indications.

5) Record the meter indication, which is the charge in coulombs (ampere-seconds) generated by the source. Meter

indication is current output of the photomultiplier integrated over the period of time of the flash pulse. This number, divided by system sensitivity at the wavelength of the Monochromator setting (system calibration curves), is integrated spectral irradiance energy contained in the flash event at that particular wavelength. Repeat the measurement at each wavelength of interest.

NOTE

Ambient compensation will change with wavelength.

TYPICAL EXAMPLE

What is the integrated spectral irradiant energy of a light source at 800 nm whose output gives a meter reading of 1×10^{-9} coulomb? System sensitivity at 800 nm is 25 coulombs/joule/cm^2 -nm.

Q_m = charge measured on meter in coulombs (C)

R_λ = System sensitivity at wavelength λ in coulombs/joule/cm^2 -nm

$$E_{800} = \frac{Q_m}{R_{800}} = \frac{1 \times 10^{-9}\ C}{25\ C/joule/cm^2\text{-nm}}$$

$$= 4.0 \times 10^{-11}\ joule/cm^2\text{-nm}$$

6) In pulse energy measurements, there exists a peak anode current above which the response is not linearly related to the input. (In practice the maximum peak-current capabilities are 1 milliampere for the Models 585-62, 585-64, and 585-66 Detector Heads and 10 milliamperes for the Model 585-63 Detector Head.) Charge is a function of both time and current; a decrease in time entails an increase in peak current for a given charge. It can be seen that for any given charge there must exist a pulse width below which nonlinearities will be introduced in the measurement, due simply to state-of-the-art limitations in response and peak-current capabilities of existing photomultipliers. Figures 55 and 56 are charts of minimum acceptable pulse widths for the Detector Heads.

NOTE

Pulse shape is also a variable.

TYPICAL EXAMPLE

For a Model 585-66 Detector Head, is a pulse width of 1×10^{-6} second acceptable for a charge indication of 1×10^{-8} coulomb? The flash-source output waveform in this case is a square wave. Using the chart in Figure 55 with a charge indication of 1×10^{-8} coulomb, the minimum acceptable pulse width for a square wave is 1.0×10^{-5} second. Therefore, the proposed setup is not satisfactory. Next, use the chart with 1×10^{-6} second. This indicates that 1×10^{-9} is the maximum charge acceptable for this particular pulse shape. Therefore, the system setup must be altered to meet these boundary conditions. Possible solutions might be to alter the source-to-Detector Head distance, to insert a calibrated aperture, reduce the Monochromator slits, etc.

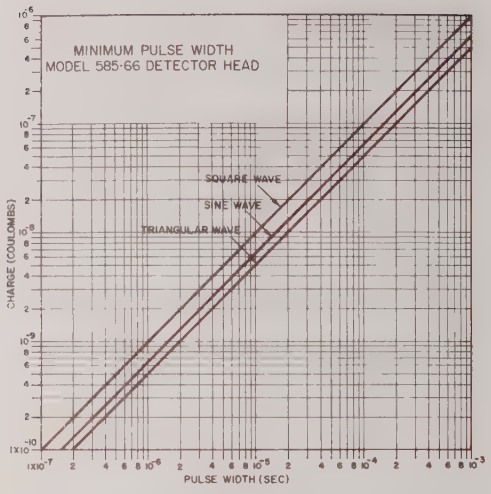


Figure 55. Minimum Pulse Width; Model 585-66 Detector Head.

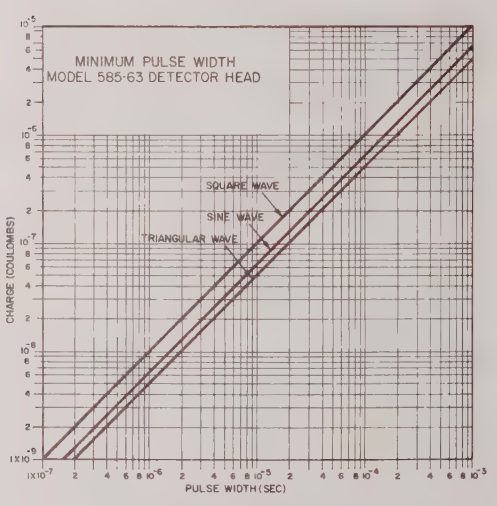


Figure 56. Minimum Pulse Width; Model 585-63 Detector Head.

4.3.6 Measuring Peak Spectral Irradiant Power, Pulse Width, and Pulse Shape

With the following exceptions, determination of peak spectral irradiant power, pulse width, and pulse shape is identical to measuring integrated spectral irradiant energy:

1) The signal switch on the Detector Head is switched to the EXT position.

2) The "external" output is connected through the SIGNAL BNC connector to a suitable oscilloscope using a termination configuration appropriate to the characteristics of the pulse being measured (see NOTE below).

3) Pulse width and pulse shape are determined directly from the oscilloscope display.

4) Peak spectral irradiant power is the peak voltage across the load (read from oscilloscope display), divided by the product of the load and the system sensitivity.

TYPICAL EXAMPLE

What is peak spectral irradiant power of a pulsed light source at 800 nm whose output gives a 12.5×10^{-3} V reading across a 50-ohm resistor? System sensitivity is 25 amp/W/cm^2 -nm at 800 nm.

V_p = peak voltage on oscilloscope display in volts

R_L = load resistance in ohms

R_λ = system sensitivity at wavelength λ in A/W/cm^2 - nm

$$E_{800\,peak} = \frac{V_p}{R_L \times R_{800}} = \frac{12.5 \times 10^{-3}}{50 \times 25}$$

$$= 1.0 \times 10^{-5}\ W/cm^2 - nm$$

NOTE

Keep in mind that the High-Sensitivity Detector Head in the oscilloscope output configuration is a true current source within the definition of that term. Thus, one can terminate in any load impedance that does not exceed the current capability and/or frequency response of the photomultiplier (Models 585-62, 585-64, and 585-66 respond to a pulse of 10-ns risetime or greater, 585-63 responds to one of 25 ns or greater). In other words, terminate in a load resistance required to give the required voltage level for oscilloscope operation, keeping in mind the need for lower resistances at higher frequencies to keep RC time constant effects from altering pulse shape.

4.4 MODEL 585 SPECTRORADIOMETER OPERATION

4.4.1 General

The following instructions explain the operational procedures necessary for proper operation of the Model 585 Spectroradiometer System when the Model 585-55 IR Detector Head is used (refer to Figure 5).

4.4.2 Basic Operating Setup

The following step-by-step procedure should be followed to obtain satisfactory operating results:

1) Select Model 585-20-10 Series Filter for range to be measured and install it in the Model 580-32 Hooded Filter Holder.

2) Connect the Filter Holder portion to the Model 585-32 Beam Input Optics.

3) Before attaching the Beam Input Optics to the Model 585-42 Chopper, select and attach appropriate Model 585-20-20 Series Fixed or Variable Slits to the Monochromator Housing determined by the amount of dispersion desired in the output beam. If it is desirable to use variable slits, proper ratios and openings must be set.

NOTE

Model 585 Spectroradiometer Systems are calibrated at the factory using Model 585-20-21 fixed slits (entrance width of 5.36 mm and exit width of 3.00 mm). This is the standard grating-slit combination, unless otherwise specified in ordering a System using a 585-55 IR Detector Head. If other slits are used, calibration accuracy must be ascertained prior to use. Bandwidth is not considered in the calculation of output, but is required in determining the steps necessary to fully evaluate a source.

4) Install appropriate Model 585-20 Series Grating into the Monochromator Housing. Grating selects spectral range to be presented to the Detector Head. Adjust the grating control for proper wavelength.

5) Connect the Detector Head to the Monochromator Housing.

6) Attach all components to the Model 585-00-12 Adapter.

7) Connect the Model 580-15 Synchronous Amplifier cable to the Model 585-42 Chopper. Operating controls for the Synchronous Amplifier are explained in subsection 2.4.

8) Connect the Chopper cable to the Detector Head.

9) If desired, the Model 585-11-11 Wavelength Transducer can be attached to the top of the grating to give a 0- to 10-mV output from beginning to end of the wavelength dial.

4.4.3 System Alignment

The Model 585 Spectroradiometer System is now ready to measure the spectral irradiance of a steady-light source. The light source to be measured must be set up with a $\pm 2.5^{\circ}$ cone working from the center of the first diffuser in the Beam Input Optics. The normal rule (for getting absolute readings) of keeping the distance from this diffuser to the source ten times the maximum source diameter also applies in order to have the source appear as a point. The first diffuser of the Beam Input Optics is always the system reference point.

4.4.4 Measurement Procedure

Set the controls as stated in Table 13, and perform the following steps:

1) To allow the Detector Head time to cool, the System should be operated for at least 5 minutes prior to the start of any measurements. Depress the Meter switch momentarily to RESET and leave in REF. A midscale reading on the meter indicates that a reference signal from the Chopper is being received properly by the Synchronous Amplifier. Place the Meter switch in the SIG position.

2) Set the Monochromator to the desired wavelength. Increase the Synchronous Amplifier sensitivity until a meter indication is obtained (i.e., adjust the AMPERE SENSITIVITY to 10^{-4}, 10^{-5}, etc). Use the METER SCALE switch to expand the signal and obtain as large an up-scale deflection as possible.

Table 13. Control Settings

CONTROL	POSITION
Synchronous Amplifier	
Ampere Sensitivity	10×10^{-3}
Meter Scale	10
Zero Suppress	OFF
Time Constant	300 ms
Meter	SIG
Frequency	10-100 Hz
Phase	As Required
Power	ON
Panel Lite	As Required
Chopper	
Power	ON
Detector Head	
Power	ON

3) Adjust the TIME CONSTANT switch as required to obtain a stable signal with a minimum response time. The TIME CONSTANT capacitors can be discharged by depressing and releasing the FILTER RESET switch.

4) Adjust the two PHASE controls to peak the signal.

5) Block the light source to be measured without disturbing other ambient light conditions. Using ZERO SUPPRESS range and vernier controls on the Synchronous Amplifier Unit, adjust for a meter indication of zero.

6) Unblock the light source to be measured, and record meter indication. With ambient conditions compensated, it may be necessary to increase the Synchronous Amplifier sensitivity to ensure sufficient up-scale deflection.

7) Repeat measurements at each wavelength of interest. Be sure to repeat compensation and to change order sorting filters as required.

8) The recorded current divided by the System sensitivity at each wavelength setting is the spectral irradiance of the source.

4.5 MODEL 585 SPECTRORADIOMETER OPERATION

4.5.1 General

The following procedures are necessary for proper operation of the Model 585 Spectroradiometer System when the Model 580-26 Silicon Detector Head is used.

4.5.2 Basic Operating Setup

The following step-by-step procedure should be followed to obtain satisfactory operating results:

1) Select Model 585-20-10 Series Filter for range to be measured, and install it in the Model 580-32 Hooded Filter Holder.

2) Connect the Filter Holder portion to the Model 585-32 Beam Input Optics.

3) Before attaching the Beam Input Optics to the Model 585-42 Chopper, select and attach appropriate Model 585-20-20 Series Fixed or Variable Slits to the Monochromator Housing determined by the amount of dispersion desired in the output beam. If it is desirable to use Variable Slits, proper ratios and openings must be set.

NOTE

Model 585 Spectroradiometer Systems are calibrated at the factory using Model 585-20-22 Fixed Slits (entrance width of 2.68 mm and exit width of 1.50 mm). This is the standard grating-slit combination, unless otherwise specified in ordering a System using a 580-26 Silicon Detector Head. If other slits are used, calibration accuracy must be ascertained prior to use. Bandwidth is not considered in the calculation of output, but is required in determining the steps necessary to fully evaluate a source.

4) Install appropriate Model 585-20 Series Grating into the Monochromator Housing. Grating selects spectral range to be presented to the Detector Head. Adjust the grating control for the proper wavelength.

5) Connect the Detector Head to the Monochromator Housing.

6) Attach all the components to the Model 585-00-11 or Model 585-00-12 Adapter.

7) Connect the Model 580-15 Synchronous Amplifier cable to the Model 585-42 Chopper.

8) Connect the Chopper cable to the Detector Head.

9) If desired, the Model 585-11-11 Wavelength Transducer can be attached to the top of the grating to give a 0- to 10-mV output from beginning to end of the wavelength dial.

4.5.3 System Alignment

The Model 585 Spectroradiometer System is now ready to measure the spectral irradiance of a steady-light source. The light source to be measured must be set up with a $\pm 2.5^{o}$ cone working from the center of the first diffuser in the Beam Input Optics. The normal rule (for getting absolute readings) of keeping the distance from this diffuser to the source ten times the maximum source diameter also applies in order to have the source appear as a point. The first diffuser of the Beam Input Optics is always the system reference point.

4.5.4 Measurement Procedure - Model 585 Spectroradiometer

Set the controls as stated in Table 14 and proceed as follows:

1) Depress the Meter switch momentarily to RESET and leave in REF. A mid-scale reading on the meter indicates that a reference signal from the Chopper is being received properly by the Synchronous Amplifier. Place the Meter switch in the SIG position.

2) Set the Monochromator to the desired wavelength. Increase the Synchronous Amplifier sensitivity until a meter indication is obtained (i.e., adjust the AMPERE SENSITIVITY to 10^{-4}, 10^{-5}, etc.). Use the METER SCALE switch to expand the signal and obtain as large an up-scale deflection as possible.

3) Adjust the TIME CONSTANT switch as required to obtain a stable signal with a minimum response time. The TIME CONSTANT capacitors can be discharged by depressing and releasing the FILTER RESET switch.

4) Adjust the two PHASE controls to peak the signal.

5) Block the light source to be measured without disturbing other ambient light conditions. Using ZERO SUPPRESS range and vernier controls on the Synchronous Amplifier Unit, adjust for a meter indication of zero.

6) Unblock the light source to be measured and record meter indication. With

Table 14. Control Settings.

CONTROL	POSITION
Synchronous Amplifier	
Ampere Sensitivity	10 x 10 -3
Meter Scale	10
Zero Suppress	OFF
Time Constant	300 ms
Meter	SIG
Frequency	10-100 Hz
Phase	As Required
Power	ON
Panel Lite	As Required
Chopper	
Power	ON
Detector Head	
Signal	Indicator
Bias	Indicator
Guard Ring	Indicator

ambient conditions compensated, it may be necessary to increase the Synchronous Amplifier sensitivity to ensure sufficient up-scale deflection.

7) Repeat the measurement at each wavelength of interest, being sure to repeat compensation and to change order sorting filters as required.

8) The recorded current divided by the System sensitivity at each wavelength setting is the spectral irradiance of the source.

4.5.5 Measurement Procedure - External Viewing

The Model 580-26 Detector Head provides a means for viewing the signal on an external instrument. For this type of operation, the SIG connector is connected to the external instrument by a BNC cable and the SIG toggle switch is set in the "down" position.

4.5.6 Measurement Procedure - Detector Head Bias

The Model 580-26 Detector Head, for either type of measurement described above, can be biased from the Synchronous Amplifier or from an external power supply. If the Synchronous Amplifier is used to bias the Detector Head, the BIAS and GUARD RING switch should be set in the INDICATOR position. If the Detector Head is to be biased externally, this switch should be set in the "down" position and the BIAS and GUARD RING connectors should be connected to the external power supply by BNC cables. (Refer to subsection 2.9.2 for details on biasing the Detector Head externally.) The 580-26 Silicon Detector is also usable with the 580-11A or 580-12 Indicator Units and has pulse and cw capability.

4.6 MODEL 585-11-11 WAVELENGTH TRANSDUCER

4.6.1 General

The following text explains the installation and alignment procedures for the Model 585-11-11 Wavelength Transducer (Figure 57).

Two mounting plates are available for use with the Model 585-11-11 Wavelength Transducer. The first (and standard) plate enables the Wavelength Transducer to be mounted directly on top of the grating. The second plate, which is intended primarily

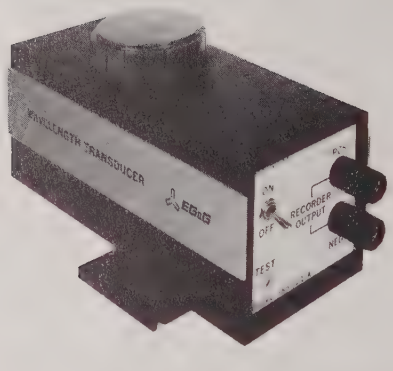


Figure 57. Model 585-11-11 Wavelength Transducer.

for use with systems using the Model 585-42 Chopper, is a side-mounting plate. The side-mounting plate is required because the Wavelength Transducer would interfere with the Chopper motor in the top mounting condition. Four long thumbscrews are provided with the side-mounting plate.

4.6.2 Basic Operating Setup

Perform the following procedures step by step:

1) Remove the plastic knob from the Monochromator grating assembly and attach the knob to the Wavelength Transducer.

2) Attach the solid aluminum knob to the grating assembly.

3) Remove the two rear captive hold-down screws on the grating assembly. Replace these screws with two long thumbscrews provided. If using the side-mounting plate, remove all four captive screws and replace with the four long thumbscrews supplied.

4) Set the Monochromator to the lowest wavelength setting (ultraviolet range: 200 nm; visible range: 350 nm; near-infrared range: 0.7 μm; intermediate infrared range: 1.4 μm).

5) Place the outer knob and spring assembly over the solid knob on the grating assembly. Do not tighten the setscrews.

6) Rotate the outer knob assembly until the setscrew (aligned with the drive pin hole on the top surface of the outer knob assembly) is aligned with the bench mark on the grating assembly. The second setscrew in the outer knob assembly should now be approximately one-third up-scale on the wavelength markings.

7) Set the Wavelength Transducer in place and tighten the thumbscrews.

NOTE

The drive pins in the knob assembly are not symmetric. If not installed properly, the Wavelength Transducer will not set squarely on the Monochromator. In this event, remove the Wavelength Transducer and turn the plastic knob until large gear and drive-pin assembly rotate 180°. Reinstall the Wavelength Transducer.

8) Check that the power switch is in the OFF position. In the bottom plate of the

Wavelength Transducer, remove the two screws nearest the Recorder output. Slide out the control panel by pulling gently on the recorder output terminals. Install battery taking note of the polarity indications on the battery holder. Reassemble the transducer by reversing the above procedure.

9) Connect an ohmmeter (1-ohm range) between the negative output terminal and the TEST jack.

10) Rotate the control knob slowly and note the lowest resistance reading.

11) Set the Monochromator wavelength dial to the lowest wavelength for that particular grating (step 4 above). (Refer to the alignment illustration given in Figure 58.)

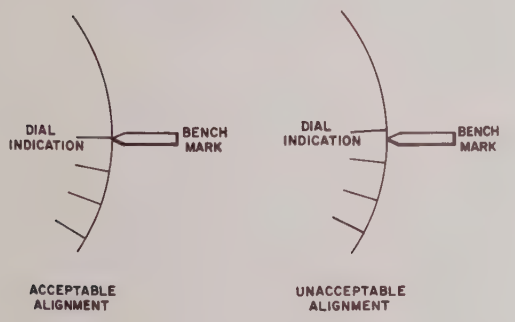


Figure 58. Wavelength Transducer Alignment.

12) Holding the wavelength dial in this position, rotate the control knob until ohmmeter is at lowest reading (step 10 above).

13) Tighten setscrews in the outer knob assembly.

14) Rotate the control knob and tighten second setscrew in outer knob assembly.

15) Recheck correlation between lowest resistance reading and lowest wavelength setting.

NOTE

Procedures in steps 10 through 15 must be completed with utmost precision. Any deviation between the lowest wavelength setting and the lowest resistance reading will result in a deviation between the actual wavelength and the indicated wavelength.

4.7 SCATTERED LIGHT IN A SPECTRORADIOMETER SYSTEM

Scattered light is an inherent problem in many Spectroradiometer Systems. The amount of scattered light present in a system varies somewhat depending on the spectral characteristics of the source being measured and the spectral response of the detector being used. Scattered light can be a serious problem in the following regions:

1) The ultraviolet when using a Model 580-25A, a Model 585-62, or a Model 585-66 Detector Head.

2) The visible from 350 to about 500 nm when using the Model 580-26 Silicon Detector Head.

These systems are supplied with the effects of scattered light removed from the calibration. Suggested methods for eliminating the effects of scattered light from measurements made in the above systems are described below.

Other possible regions where the effects of scattered light could seriously affect the accuracy of the readings occur at the upper wavelength limits of the Detector Head response, where their sensitivities are falling off rapidly. The unavailability of sharp cut-on filters in these regions limits the degree to which scattered light correction can be obtained here.

A Spectroradiometer System using the Model 585-66 (S-10), Model 585-62 (S-20), or Model 580-25A (S-5) Detector Heads (200 to 800 nm) can suffer from scattered light effects in the ultraviolet. This problem develops when the energy in the visible region is much greater than the energy in the ultraviolet below 280 nm. The 0.3% scattering of the ultraviolet grating that develops can be an appreciable amount of the energy being received by the photocathode surface at the lower wavelengths. In general, this problem is only serious in the 200- to 280-nm region.

A simple technique is recommended to correct this scattered light problem:

1) Set the grating dial to approximately 160 nm. This wavelength is not indicated on the dial but is easy to approximate.

2) Without the use of order sorting filters, make a current reading at this wavelength. Since there is no light being transmitted by the system at this wavelength, the signal current is a direct measure of the scattered light.

3) Subtract this current reading from the signal current readings taken from 200 nm and up to obtain the actual energy related current for each wavelength. For wavelengths greater than 280 nm, the scattered-light effect should become negligible with respect to the signal.

A Spectroradiometer System using the Model 580-26 Silicon Detector Head may suffer from the effects of scattered light in the spectral region from 350 to 550 nm. The recommended technique for correcting for scattered light in this system is similar to the procedure outlined above for the ultraviolet region.

1) Install both the 7-54 and the 0-52 filters in the Hooded Filter Holder.

2) Set the grating dial to approximately 330 nm. This wavelength is not indicated on the dial but it is easy to approximate.

3) Take a current reading, I_1. Since there should be no light being transmitted by the 0-52 filter (transmission less than 0.1% at 330 nm), the signal current, after correcting for the average transmission of the 0-52 filter, is a direct measure of the scattered light.

4) The corrected reading is $I_1/0.9$. Subtract this value from the signal values obtained from 350 to 380 nm to obtain the true signal current.

5) Remove the 7-54 filter from the Hooded Filter Holder, leaving just the 0-52 filter.

6) Set the grating dial to approximately 330 nm.

7) Take a current reading I_2. This is the scattered light correction factor for the region 380 to 550 nm.

8) Subtract this reading from the signal current readings taken from 380 to 550 nm to obtain the true signal current. For those wavelengths where the current due to scattered light is less than 1% of the signal current, the correction can be neglected.

An alternate approach to the correction techniques described above is to use a double monochromator system to reduce the amount of scattered light that reaches the Detector Head. Two monochromators can be used end to end to reduce scattered light. The amount of reduction will vary with source-detector characteristics from 1 to 3 decades with a minimum reduction in signal throughput.

SECTION 5

CALIBRATION

5.1 GENERAL

Before shipment each system is calibrated at the factory using calibration equipment traceable to the National Bureau of Standards. Three copies of the calibration data for each system are furnished.

5.2 RADIOMETER CALIBRATION

A Radiometer System is shipped as a fully calibrated system. Each Detector Head, Indicator Unit, Narrow-Beam Adapter, and Laser-Beam Sampler is individually calibrated. Data sheets tabulating the absolute spectral response is shipped with each Detector Head (Figure 59).

The radiometric calibration data are given in units of amp/W/cm^2 at each wavelength. These are the units that would be used for measuring the irradiant power of a steady source. If the time-integrated irradiant power of a pulsed source is to be measured, the equivalent units would be coulombs/joules/cm^2 at each wavelength.

Photometric calibration constants are also supplied on the data sheets where applicable. The data are given in units of amp/lumen/ft^2 and in amp/lumen/cm^2, the units that would be used for measuring the luminous power of a steady source. If a pulsed source is to be measured, the equivalent units would be coulombs/lumen-sec/ft^2 and coulombs/lumen-sec/cm^2.

The sensitivity data supplied provide the simple basis on which current and charge measurements (proportional to the light-source output) are converted to irradiant (or luminous) power and energy values.

5.2.1 Detector Head Calibration — Visible and Infrared

The radiometric calibration of a given Detector Head, in amp/W/cm^2, is determined by the following procedure over the spectral region 350 to 1150 nanometers:

1) An irradiance source and a set of narrow-band filters are used to produce, at a set distance, a known amount of irradiant power at 25-nanometer increments across the useful bandwidth of the detector to be calibrated. The amount of irradiant power in the passband of each filter is measured by a calibrated thermopile

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TEST NO. 1051
EG&G INC

580/585 RADIOMETER CALIBRATION

MODEL NO.	DESCRIPTION	S/N
580-22A	DETECTOR HEAD	549
580-00-33	PHOTOMETRIC FILTER	549

TRACEABILITY TO NBS - STANDARD LAMP NO. A111A

TRACEABILITY TO NBS - THERMOPILE S/N B-4620

CERTIFICATE NO. 580-22A-549-1B

CALIBRATED BY DATE 10/22/71

EG&G CERTIFIES THAT THE CALIBRATION PRESENTED HEREIN WAS PERFORMED USING STANDARDS TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS.

PHOTOMETRIC SENSITIVITY

ILLUMINANCE

A/LUMEN/SQ-CM	A/LUMEN/SQ-FT
6.16E-06	6.63E-09

WAVELENGTH NANOMETERS	SENSITIVITY A/W/SQ-CM
350	1.13E-02
360	1.30E-02
370	1.47E-02
380	1.62E-02
390	1.75E-02
400	1.82E-02
410	1.84E-02
420	1.83E-02
430	1.84E-02
440	1.87E-02
450	1.92E-02
460	1.96E-02
470	2.01E-02
480	2.07E-02
490	2.13E-02
500	2.17E-02
510	2.20E-02
520	2.21E-02
530	2.22E-02
540	2.23E-02
550	2.21E-02
560	2.16E-02
570	2.08E-02
580	1.99E-02
590	1.88E-02
600	1.77E-02
610	1.65E-02
620	1.51E-02
630	1.36E-02
640	1.18E-02
650	1.01E-02
660	8.44E-03
670	6.91E-03
680	5.48E-03
690	4.18E-03
700	3.09E-03
710	2.26E-03
720	1.64E-03
730	1.15E-03
740	7.69E-04
750	4.81E-04
760	2.84E-04
770	1.60E-04
780	8.78E-05
790	4.84E-05
800	2.85E-05
488.0	2.13E-02
514.5	2.24E-02
632.8	1.32E-02
694.3	3.79E-03

Figure 59. Data Sheets - Model 580/585 Radiometer Calibration.

traceable to the National Bureau of Standards. The ratio of thermopile voltage to the thermopile calibration constant ($\mu V/\mu W/cm^2$) is the irradiant power.

2) The Detector Head under calibration is then placed in the same position, with its diffuser fully illuminated, as the thermopile. A set of current readings is then taken with each narrow-band interference filter.

3) The ratio of detector current to irradiant power, as measured by the thermopile, is the absolute detector sensitivity at calibration wavelengths (amp/W/cm^2).

4) The sensitivity readings are then interpolated, via a computer, to obtain sensitivity values at 10-nanometer increments across useful bandwidth of detector.

5) Sensitivity values for various laser wavelengths are also measured for each system and are tabulated on the data sheets.

6) A near IR system has two sensitivity values tabulated at 1060 nm. The 1060-nm sensitivity value listed in the laser wavelength section is the measured sensitivity and the 1060-nm sensitivity value listed in the main section is an interpolated value.

5.2.2 Radiometer Calibration – Ultraviolet (UV)

The radiometric calibration of a Detector Head in the UV from 200 to 350 nanometers, given in amp/W/cm^2, is determined by use of the following procedures:

1) Thermopile measurements of relative exit-beam power of a constant light source/Monochromator combination are made at 10-nanometer increments across the useful bandwidth of the detector (200 to 350 nanometers).

2) The detector under calibration is then substituted for the thermopile at the Monochromator exit optics, and measurements are taken at the same wavelength settings as used with the thermopile. Scattered light effects are accounted for as described in section 4.7.

3) The ratio of detector current/thermopile voltage at corresponding wavelength settings provides data for relative spectral response of the detector under calibration.

4) An irradiance source and a narrow-band interference filter are then used to produce a known amount of irradiant power at 350 nanometers at a set distance. The amount of irradiant power is measured by a calibrated thermopile traceable to the National Bureau of

Standards. A Detector Head is placed in the same position with the diffuser fully illuminated. The ratio of the output current of the detector under calibration to the incident irradiant power as measured with the thermopile is the absolute detector sensitivity ($A/W/cm^2$) at the calibration wavelength.

5) The relative spectral response of the detector is then scaled by the normalization factor at 350 nm to obtain the absolute spectral sensitivity ($A/W/cm^2$) of the detector.

5.2.3 Photometric Calibration

A photometric calibration can be supplied with the Model 580-22A (S20), the Model 580-25 (S5), the Model 585-62 (S20), or the Model 585-66 (S10) Detector Heads. For each of these systems, the spectral response of the detector is filter-corrected to approximate the standard luminosity response. The photometric calibration of the above Detector Heads is determined from its response to a 1000W standard lamp whose illuminance is known.

On request, a photometric calibration can be provided for the Model 580-25A Detector Head against a $6000^{o}K$ flash standard.

5.2.4 Aperture Calibration

Aperture calibration is in accordance with the following. Using an irradiance source, the initial aperture indication is set to a convenient value by observing the Indicator Unit and adjusting the position of the Detector Head. For each consecutive setting of the APERTURE MULTIPLIER switch, the applicable aperture trimmer is adjusted to give the proper ratio to the original setting.

5.2.5 Model 580-00-11 Narrow-Beam Adapter Calibration

The calibration of the Narrow-Beam Adapter (Figure 60) relates to the following equation that expresses the transmission at any wavelength using an irradiance source of light:

$$\tau = \frac{I_2}{I_1} \frac{1}{A} \frac{(d_2)^2}{(d_1)^2} = w/cm^2/w$$

where

E_1 = output of Detector Head at a wavelength determined by the filter used

E_2 = output of Detector Head with the Narrow-Beam Adapter and precision aperture at the same wavelength (same filter)

A = area of precision aperture

d_1 = distance from light source to first diffuser of Detector Head

d_2 = distance from light source to first diffuser of Narrow-Beam Adapter

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TEST NO. 1040
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NARROW BEAM ADAPTER CALIBRATION
580-00-11 S/N 250

WAVELENGTH NANOMETERS	SENSITIVITY W/SQ-CM/W
350	5.81E-04
375	7.42E-04
400	8.77E-04
450	9.60E-04
500	1.00E-03
550	1.05E-03
600	1.14E-03
650	1.11E-03
700	1.12E-03
750	1.17E-03
800	1.24E-03
850	1.26E-03
900	1.27E-03
950	1.31E-03
1000	1.35E-03
1050	1.40E-03
1100	1.44E-03
1150	1.44E-03
488.0	9.87E-04
514.5	1.01E-03
632.8	1.11E-03
694.3	1.11E-03
1060.	1.41E-03

CERTIFICATE NO.580-00-11-250-1
CALIBRATED BY DATE 11/01/71

Figure 60. Data Sheet - Model 580-00-11 Narrow-Beam Calibration.

5.2.6 Conversion of Data

Measurements are made with the Model 580 Radiometer in terms of a meter or recorder display of charge or current, or an oscilloscope display of voltage waveforms. These measurements are directly related to the source output, and conversion to irradiant (or luminous) units is made by application of the proper calibration constants and multipliers. The following data-conversion formulas apply for any monochromatic irradiance of wavelength (radiometric), or any illuminance from a source intended for a visual application (photometric) where:

I_m = current measured on meter in amperes

Q_m = charge measured on meter in coulombs

V_m = peak voltage measured on oscilloscope

M_a = value of Detector Aperture Multiplier

M_v = voltage multiplier setting on Detector

when

$M_v = 1$, R_{load} = 5K ohms

$M_v = 10$, R_{load} = 500 ohms

$M_v = 100$, R_{load} = 50 ohms

$K_{1\lambda}$ = radiometric sensitivity constant for Detector Head at any wavelength in:

$$\frac{\text{amp}}{\text{watt/cm}^2} \quad \text{or} \quad \frac{\text{coulombs}}{\text{joule/cm}^2}$$

$K_{2\lambda}$ = radiometric voltage-sensitivity constant for Detector Head in

$$\frac{\text{volts}}{\text{watt/cm}^2} = K_{1\lambda} \; R_{load}$$

K_3 = photometric sensitivity constant for Detector with luminosity filter in

$$\frac{\text{amp}}{\text{lumen/ft}^2} \quad \text{or} \quad \frac{\text{coulombs}}{\text{lumen-sec/ft}^2}$$

K_4 = photometric voltage-sensitivity constant for Detector with luminosity filter in

$$\frac{\text{volts}}{\text{lumen/ft}^2} = K_3 R_{load}$$

RADIOMETRIC	PHOTOMETRIC
Monochromatic Irradiance	Any Visual Source

STEADY SOURCE

Average Irradiant Power (E_e)	Average Luminous Power (E_v)
$E_e = \frac{I_m M_a}{K_{1\lambda}}$ in $\frac{\text{watts}}{\text{cm}^2}$	$E_v = \frac{I_m M_a}{K_3}$ in $\frac{\text{lumens}}{\text{ft}^2}$

PULSED SOURCE

Integrated Irradiant Energy (E_e)	Integrated Luminous Energy (E_v)
$E_e = \frac{Q_m M_a}{K_{1\lambda}}$ in $\frac{\text{joules}}{\text{cm}^2}$	$E_v = \frac{Q_m M_a}{K_3}$ in $\frac{\text{lumen-sec}}{\text{ft}^2}$

Peak Irradiant Power (E_e)	Peak Luminous Power (E_v)
$E_e = \frac{V_m M_a}{K_{2\lambda}}$ in $\frac{\text{watts}}{\text{cm}^2}$	$E_v = \frac{V_m M_a}{K_4}$ in $\frac{\text{lumens}}{\text{ft}^2}$

Additional information can be obtained when pulsed-light waveforms are scope displayed, such as:

a. The waveshape can be determined.

b. The pulse risetime, fall time, and duration can be measured directly from the trace against the oscilloscope time base.

c. Peak signal voltage can be observed for conversion to peak-power measurements for repetitive waveforms or peak-power measurements for transient pulses.

5.2.7 Relative Measurements

Relative measurements of any source irradiance can be made with the Model 580 Radiometer provided the source spectrum is covered by the Model 580-20A or 585-60 Series Detector Heads selected.

5.2.8 Photometric Measurements

Detectors supplied with a photometric calibration have a net spectral response (detector-photometric filter) which closely follows the standard luminosity curve. Model 580 measurements with sources intended for visual applications are therefore absolute measurements.

5.2.9 Radiometric Measurements

Proper Model 580 measurements are absolute where source irradiance is monochromatic and of a known wavelength. Absolute measurements with chromatic sources require knowledge of the spectral characteristics of the source (irradiant) power or energy versus wavelength . Total absolute power of energy of a heterochromatic source is the summation of the incremental contribution of the power or energy at each wavelength. This measurement is best performed with an instrument like the EG&G Model 580/585 Spectroradiometer. The Model 580/585 operates compatibly with the Model 580

Radiometer to directly characterize an irradiant source. Absolute measurements in watts (or joules) per cm^2 can be made at intervals across the Model 580 spectral range. The summation of these incremental readings is the total power or energy of the chromatic source as seen by the Detector Head.

5.3 MODEL 585 AND 580/585 SPECTRORADIOMETER CALIBRATION

5.3.1 Calibration Data

The calibration data are supplied for the Model 580/585 Spectroradiometer System on a calibration chart as shown in Figure 61. The chart contains all the model and serial numbers of all the units/components used in the calibration. The data are obtained by one of the procedures given below depending on the spectral range being covered.

The Model 580/585 Spectroradiometer System is calibrated in the visible and IR region, 350 to 1600 nanometers, by the following procedure:

1) The reference surface, normally the first diffuser system of the Beam Input Optics, is set at a specified distance from a 1000W standard lamp whose calibration is traceable to the National Bureau of Standards. The distance is set to obtain as high an on-scale reading as possible from the system under calibration.

2) A set of current readings is taken at specific intervals over the region being calibrated.

3) The ratio of detector current to the irradiance incident on the system at each wavelength is the absolute spectral sensitivity, in amp/W/cm^2-nm, of the system under calibration.

In the infrared region, 1600-3200 nanometers, the Model 580/585 Spectroradiometer System is calibrated by the following procedure:

1) The reference surface, normally the first diffuser system of the Beam Input Optics, is set at a specified distance from a blackbody. The temperature of the blackbody is monitored by an internal thermocouple. The radiance of the blackbody can then be computed from Planck's equation and, from this, the irradiance incident on the system can be calculated.

2) The entire calibration setup is enclosed in a small area, which is flushed with dry nitrogen to eliminate the atmospheric water absorption bands.

3) A set of current readings is taken at specific intervals over the region being calibrated.

4) The ratio of detector current to the irradiance incident on the system at each wavelength is the absolute sensitivity, in amps/W/cm^2, of the system under calibration.

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TEST NO. 1093
EG&G INC

580/585 SPECTRORADIOMETER CALIBRATION

MODEL NO.	DESCRIPTION	S/N
580-23A	DETECTOR HEAD	536
585-11	MONOCHROMATOR HOUSING ASSEMBLY	240
585-22	MONOCHROMATOR GRATING	280
585-20-22	MONOCHROMATOR SLITS B	
	ORDER SORTING FILTERS	
585-20-17	CS NO. 7-54 350 NM - 380 NM	
585-20-16	CS NO. 0-52 380 NM - 550 NM	
585-20-12	CS NO. 3-69 550 NM - 700 NM	
585-20-13	CS NO. 2-64 700 NM - 800 NM	
585-32	BEAM INPUT OPTICS	149

TRACEABILITY TO NBS - STANDARD LAMP NO. A141A

CERTIFICATE NO. 580-234-536-1B

CALIBRATED BY DATE 07/30/71

EG&G CERTIFIES THAT THE CALIBRATION PRESENTED HEREIN WAS PERFORMED USING STANDARDS TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS.

PAGE 2
TEST NO. 1093
EG&G INC

WAVELENGTH NANOMETERS	SENSITIVITY A/W/SQ-CM-NM	FILTER CS NO.
350	5.97E-05	7-54
360	5.72E-05	"
370	5.19E-05	"
380	4.16E-05	"
380	4.58E-05	0-52
390	4.25E-05	"
400	3.73E-05	"
410	3.20E-05	"
420	2.81E-05	"
430	2.64E-05	"
440	2.53E-05	"
450	2.47E-05	"
460	2.44E-05	"
470	2.44E-05	"
480	2.40E-05	"
490	2.37E-05	"
500	2.36E-05	"
510	2.34E-05	"
520	2.30E-05	"
530	2.20E-05	"
540	2.14E-05	"
550	2.13E-05	"
550	1.86E-05	3-69
560	1.95E-05	"
570	1.99E-05	"
580	2.02E-05	"
590	2.04E-05	"
600	2.06E-05	"
610	2.04E-05	"
620	2.01E-05	"
630	1.98E-05	"
640	1.95E-05	"
650	1.93E-05	"
660	1.89E-05	"
670	1.86E-05	"
680	1.83E-05	"
690	1.80E-05	"
700	1.77E-05	"
700	1.70E-05	2-64
710	1.71E-05	"
720	1.69E-05	"
730	1.68E-05	"
740	1.65E-05	"
750	1.62E-05	"
760	1.59E-05	"
770	1.56E-05	"
780	1.54E-05	"
790	1.50E-05	"
800	1.45E-05	"

Figure 61. Data Sheets - Model 580/585 Spectroradiometer Calibration.

In the UV region (200-400 nanometers) the Model 580/585 Spectroradiometer System is calibrated by the following procedure:

1) The system is set at a distance from a deuterium source whose relative spectral output is known.

2) A set of current readings is taken at specific wavelength intervals – from 200 to 350 nanometers.

3) The ratio of detector current to relative irradiance is the relative response of the system from 200 to 350 nanometers.

4) The deuterium source is removed and the reference surface of the system is set at a specified distance from a 1000W standard lamp.

5) A set of current readings is taken from 350 to 400 nanometers.

6) The ratio of detector current to irradiance incident on the system is the absolute sensitivity of the system in amp/W/cm^2 from 350 to 400 nanometers.

7) Using the normalization factor between the absolute and relative sensitivities obtained at 350 nanometers, the relative data are converted to absolute sensitivities from 200 to 350 nanometers.

Model 585 and 580/585 Spectroradiometer calibrations are done with a specific set of fixed slits, depending on the spectral region and the type of calibration. These calibrations can be transferred to any other of the fixed slits by simply setting up a steady light source and taking a set of current readings with the calibrated slits. Readings derived with the new pair of slits allow the reader to establish a ratio between the different pairs of slits. This ratio, in turn, permits the use of the calibration curve.

5.4 MODEL 580-10 SERIES INDICATOR UNIT CALIBRATION

5.4.1 Model 580-11A Indicator Unit Calibration

To eliminate or minimize troubles during calibration, perform the following functional checks of the unit:

1) Check electrical and mechanical zero of meter.

2) Check meter down-scale leakage.

3) Check COMPENSATION circuit.

4) Check charge sequence.

5) Check X3 MULTIPLIER scaling.

6) Check CURRENT DAMPING control.

7) Check ZERO ranging.

8) Check panel lights.

For current calibration, the current-range potentiometers for the X10^{-6} through X10^{-11} current-range scales are adjusted for exact full-scale meter deflection using a precise current source (0.1%).

For charge calibration, the charge-range potentiometers for the X10^{-7} through

$X10^{-11}$ charge-range scales are adjusted for exact full-scale meter deflection using a precise charge source (0.1%).

5.4.2 Model 580-12 Digital Indicator Unit Calibration

To eliminate or minimize troubles during calibration, perform the following functional checks of the unit:

1) Check electrical zero of digital panel meter.

2) Check meter down-scale leakage.

3) Check COMPENSATION circuit.

4) Check charge sequence.

5) Check CURRENT DAMPING control.

6) Check ZERO ranging.

7) Check mechanical zero and gain of analog meter.

8) Check BCD outputs.

For current calibration, the current-range potentiometers for the $X10^{-6}$ through $X10^{-11}$ current-range scales are adjusted for exact full-scale meter deflection using a precise current source (0.1%).

For charge calibration, the charge-range potentiometers for the $X10^{-7}$ through $X10^{-11}$ charge-range scales are adjusted for exact full-scale meter deflection using a precise charge source (0.1%).

5.4.3 Model 580-15 Synchronous Amplifier Calibration

To eliminate or minimize troubles during calibration, the following functional checks of the Unit are made:

1) Check of mechanical zero of meter.

2) Check of reference signal from chopper.

3) Check of zero suppress circuit.

4) Check of 10-5-2 meter scaling.

5) Check of time constant control.

6) Check of zero ranging.

7) Check of panel lights.

8) Check of phase controls.

9) Check of frequency range control switch.

For current calibration, a precise (0.1%) square wave of current at a frequency of 87 Hz is used to set the amplifier gain.

SECTION 6

MAINTENANCE

6.1 GENERAL

Maintenance other than external cleaning of System components is not advised. Surface mirrors, extremely critical internal adjustments, etc., could be damagingly and permanently altered if maintenance is attempted by other than factory specialists.

6.2 CLEANING

If cleaning of external surfaces is necessary, care should be exercised to prevent water, cleaning liquids, and other foreign substances from working or leaking through assembly housings to internal components. Diffuser discs, glass input optics, and beam input lenses should be cleaned with a commercially recognized lens cleaner only.

NOTE

Assemblies and components not in use should be stored in their respective protective cases.

6.3 SCHEMATICS

Schematic diagrams (Figures 62-79) for all electronic components of the Systems are provided on the following pages.

6.4 EQUIPMENT RETURN

If it is necessary to return equipment to the factory for maintenance or calibration, please furnish information as to difficulty, calibration desired, etc.

NOTE

Opening Indicator Unit or Detector Head voids warranty.

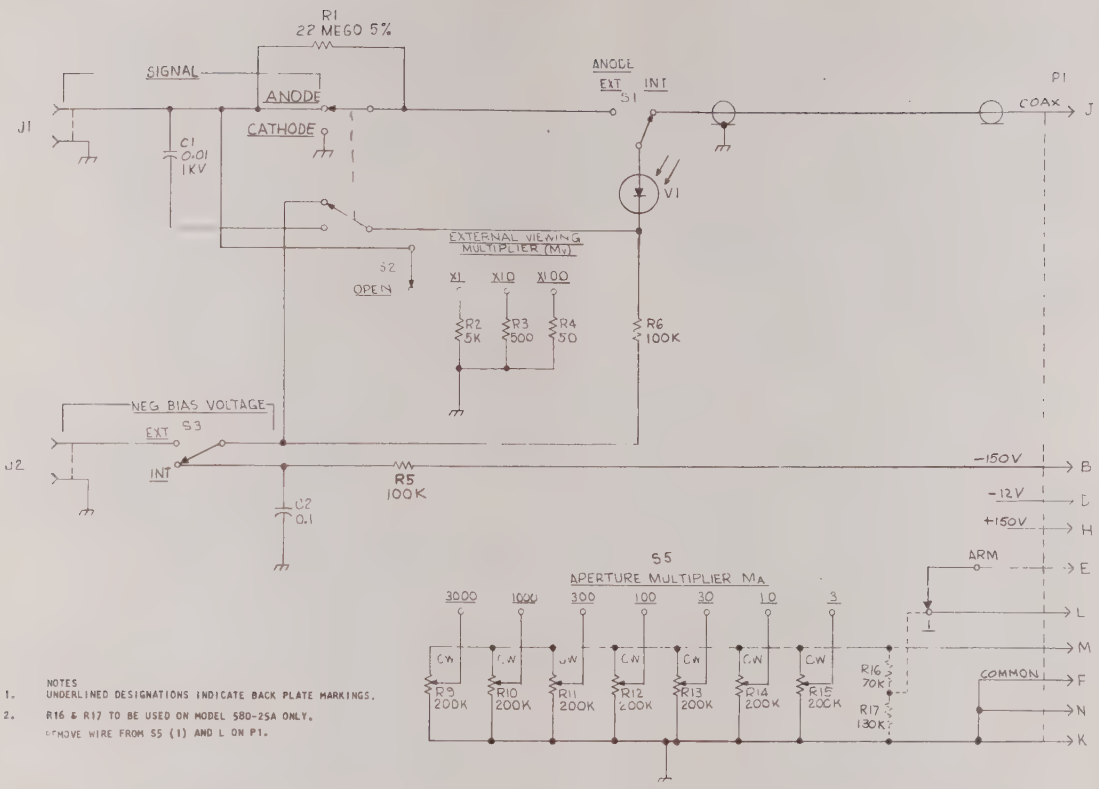


Figure 62. Schematic Diagram, Model 580-20A Series Detector Heads.

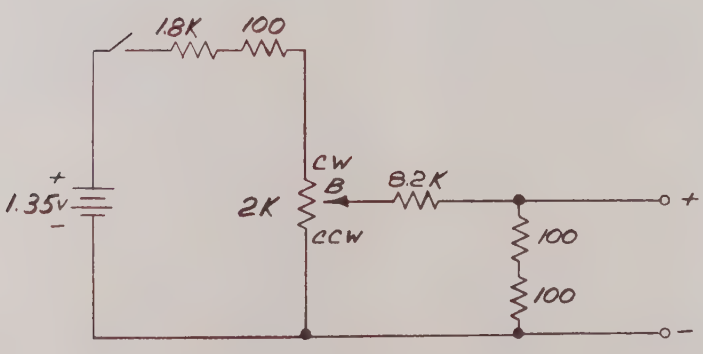
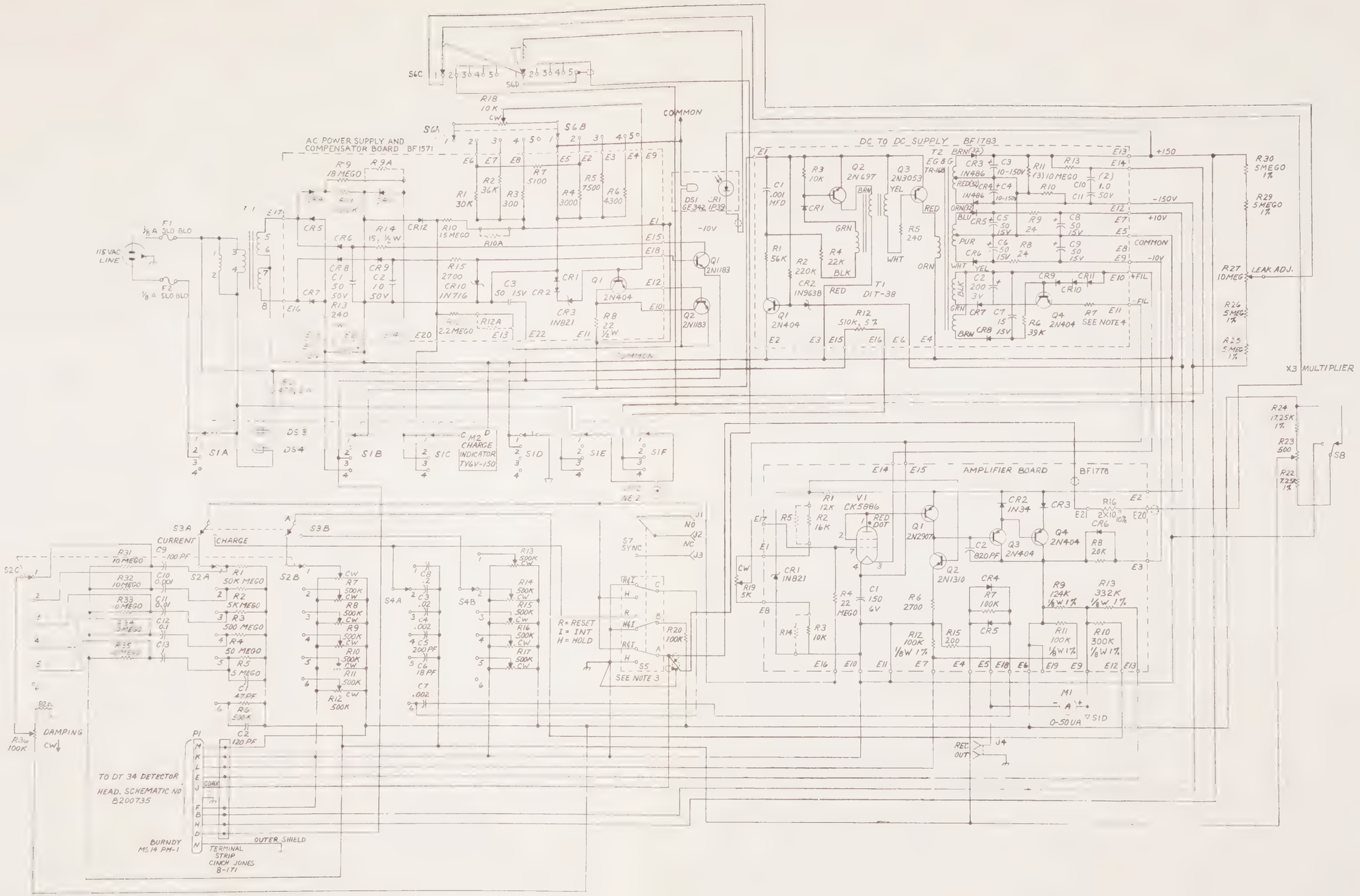


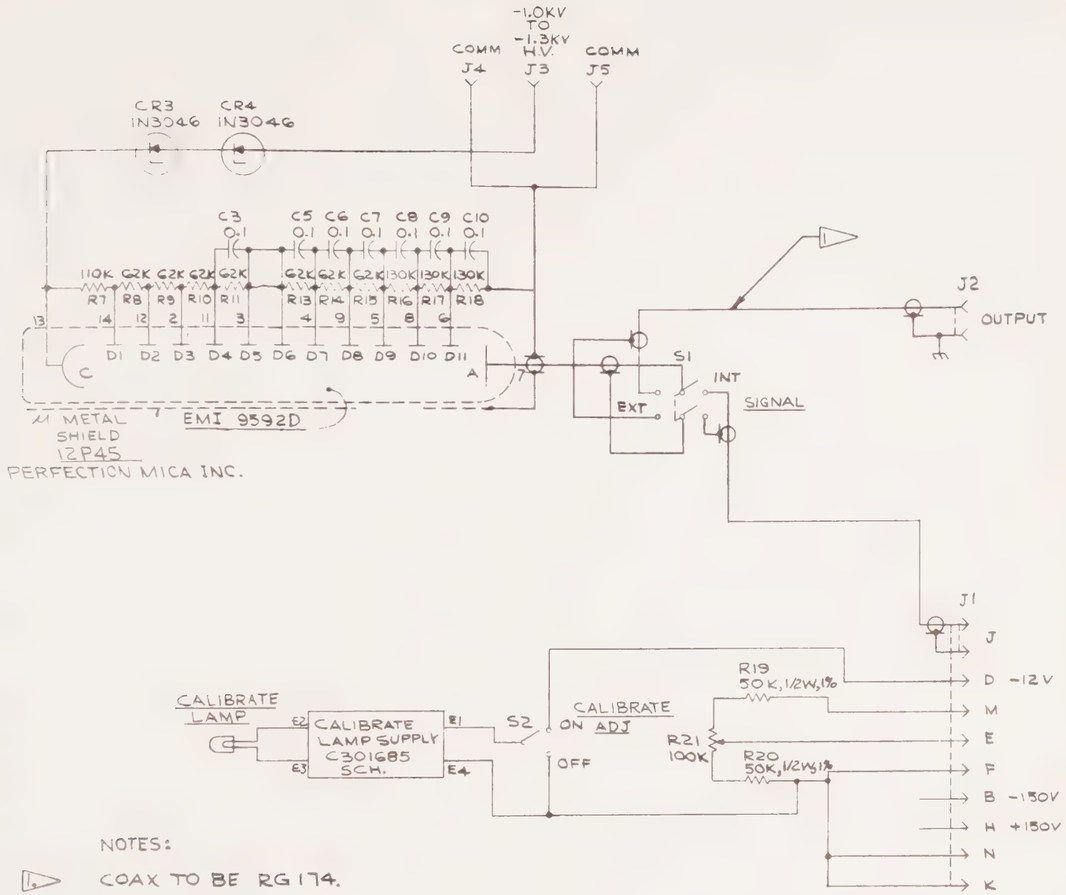
Figure 63. Model 585-11-11 Wavelength Transducer.



NOTES

1. R9A, R10A, R12A TO BE ADDED WHEN LARGER BATTERY IS USED TO HOLD CHARGING TIME VALUES ARE EQUAL TO R9, 10 & 12 RESPECTIVELY.
2. R5&R14 ON AMPL. BD. ARE TO ALLOW FOR ASSEMBLY ADJUST OF CIRCUIT BIAS.
3. SWITCHES S5 & S7 SHOWN INTEGRATE POSITION.
4. R7 FOR ASSEMBLY ADJUST OF FILAMENT VOLTAGE (10-30Ω).
5. THIS NETWORK IS ADDED ACROSS EACH OF THE VICTOREEN RESISTORS ON THIS SECTION OF S2 (A) WITH THE EXCEPTION OF POS #6.

Figure 64. Schematic Diagram, Model 580-11A Indicator Unit.



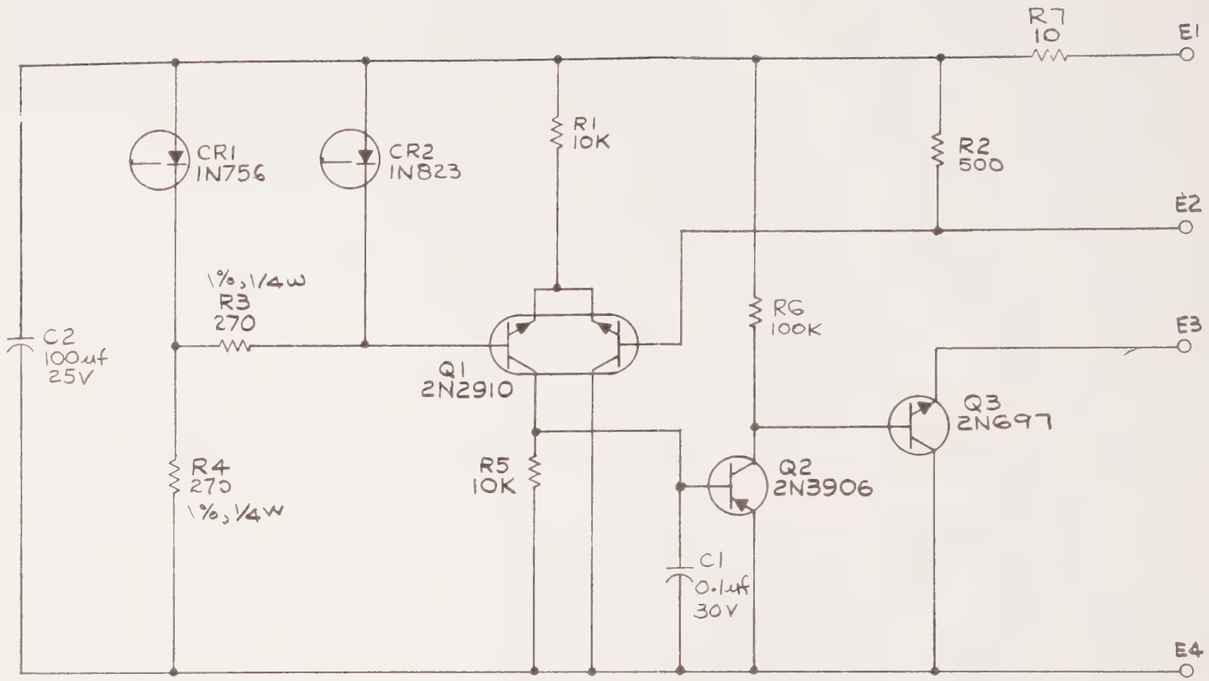
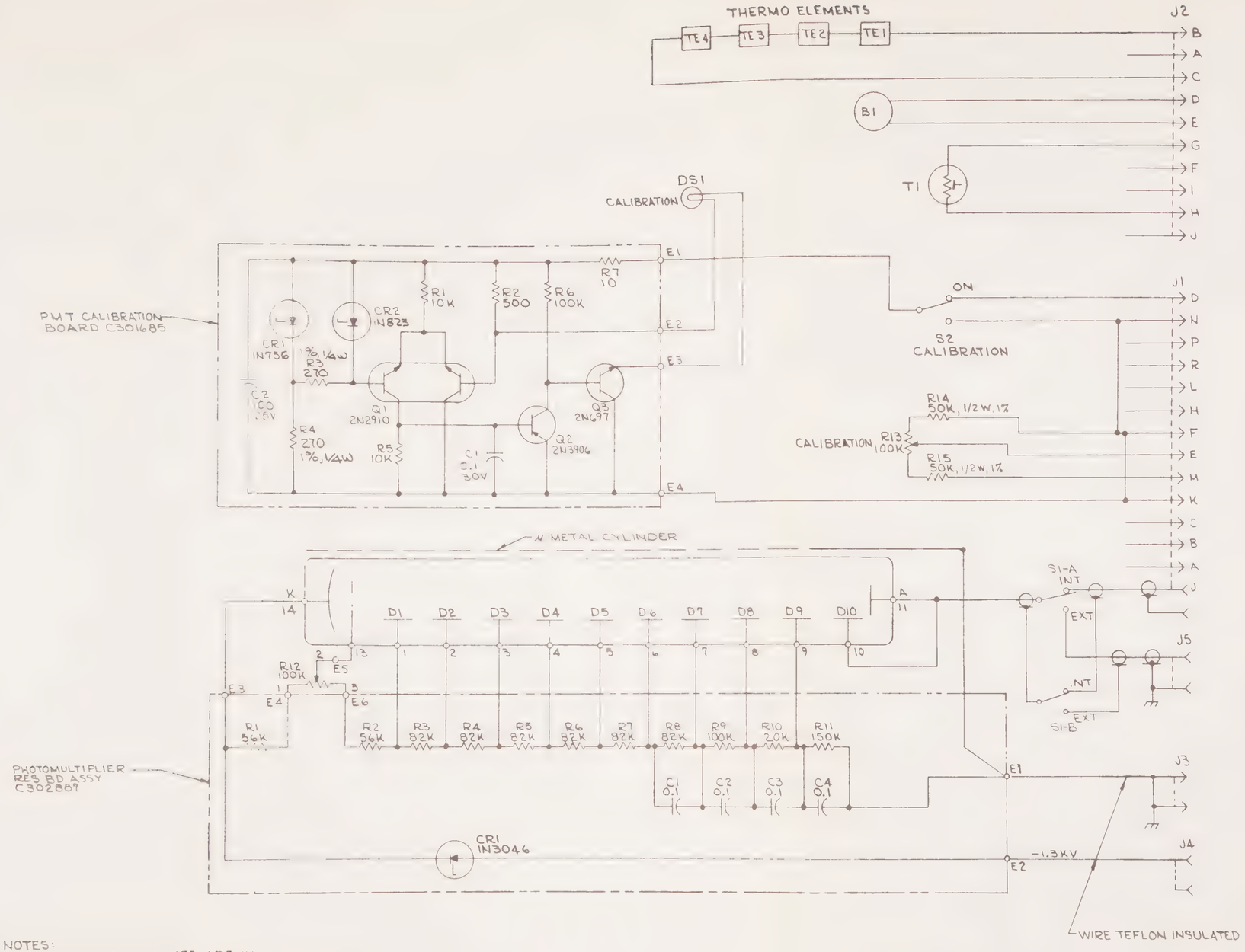
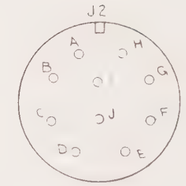
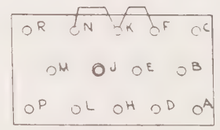


Figure 65. Schematic Diagram, Model 585-66 High-Sensitivity Detector Head.







NOTES:
1. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ALL RESISTORS ARE 1/4W 5% AND IN OHMS UNLESS OTHERWISE SPECIFIED.

Figure 66. Schematic Diagram, Model 585-63 High-Sensitivity Detector Head.

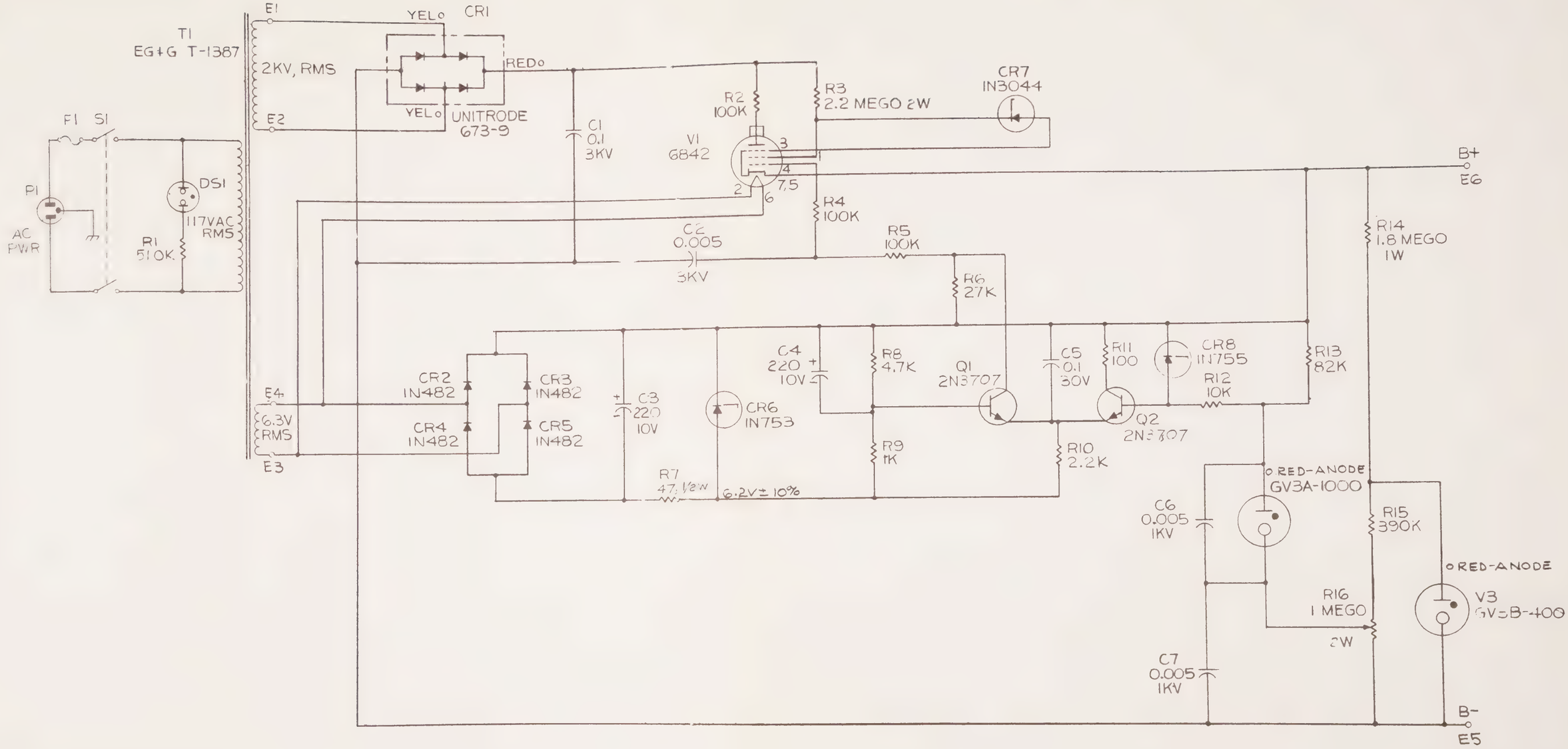


Figure 67. Schematic Diagram, Model 580-00-60 Power Supply.

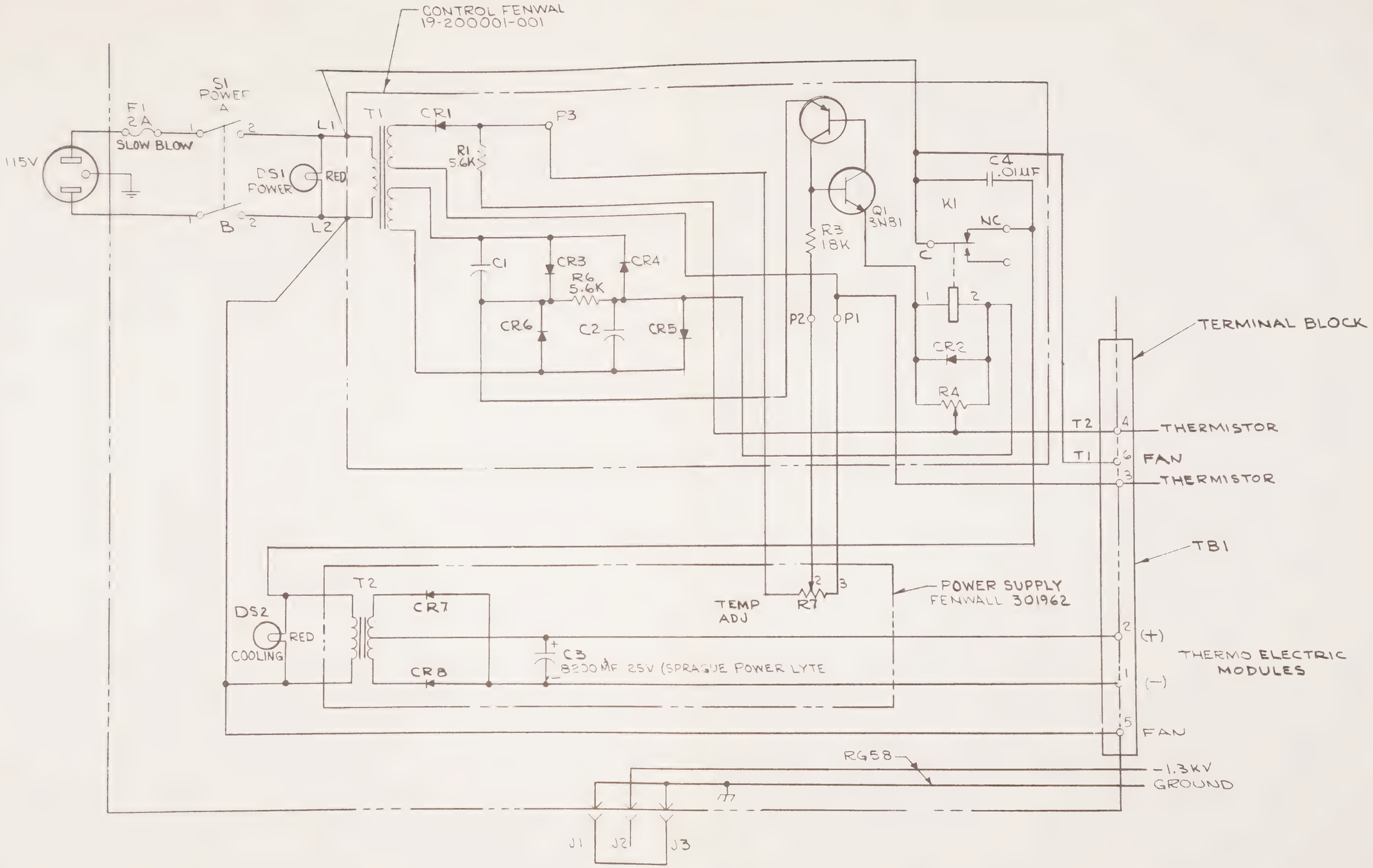


Figure 68. Schematic Diagram, Model 585-00-63 Controller.

NOTES:

1. STUD OF DIODE PACKAGE TO CHASSIS GROUND.
2. SHIELD ISOLATED FROM GROUND.

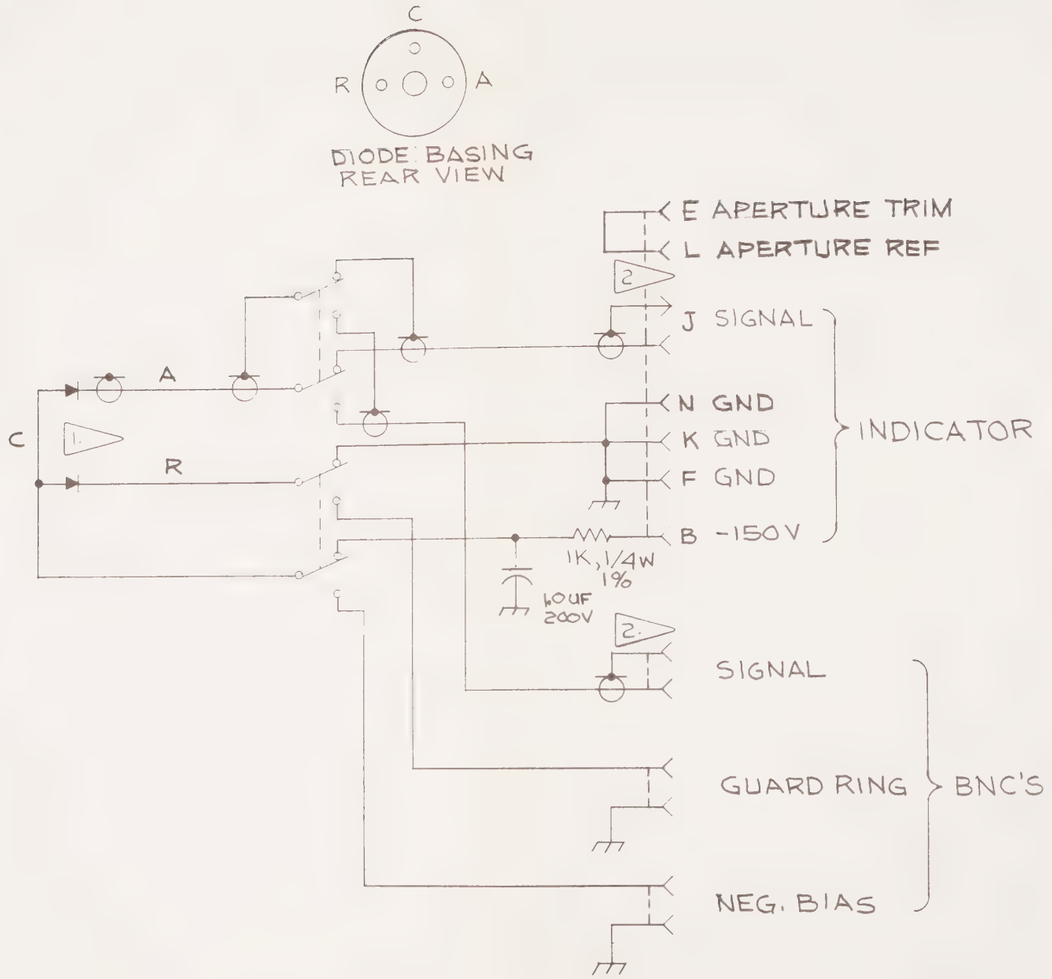
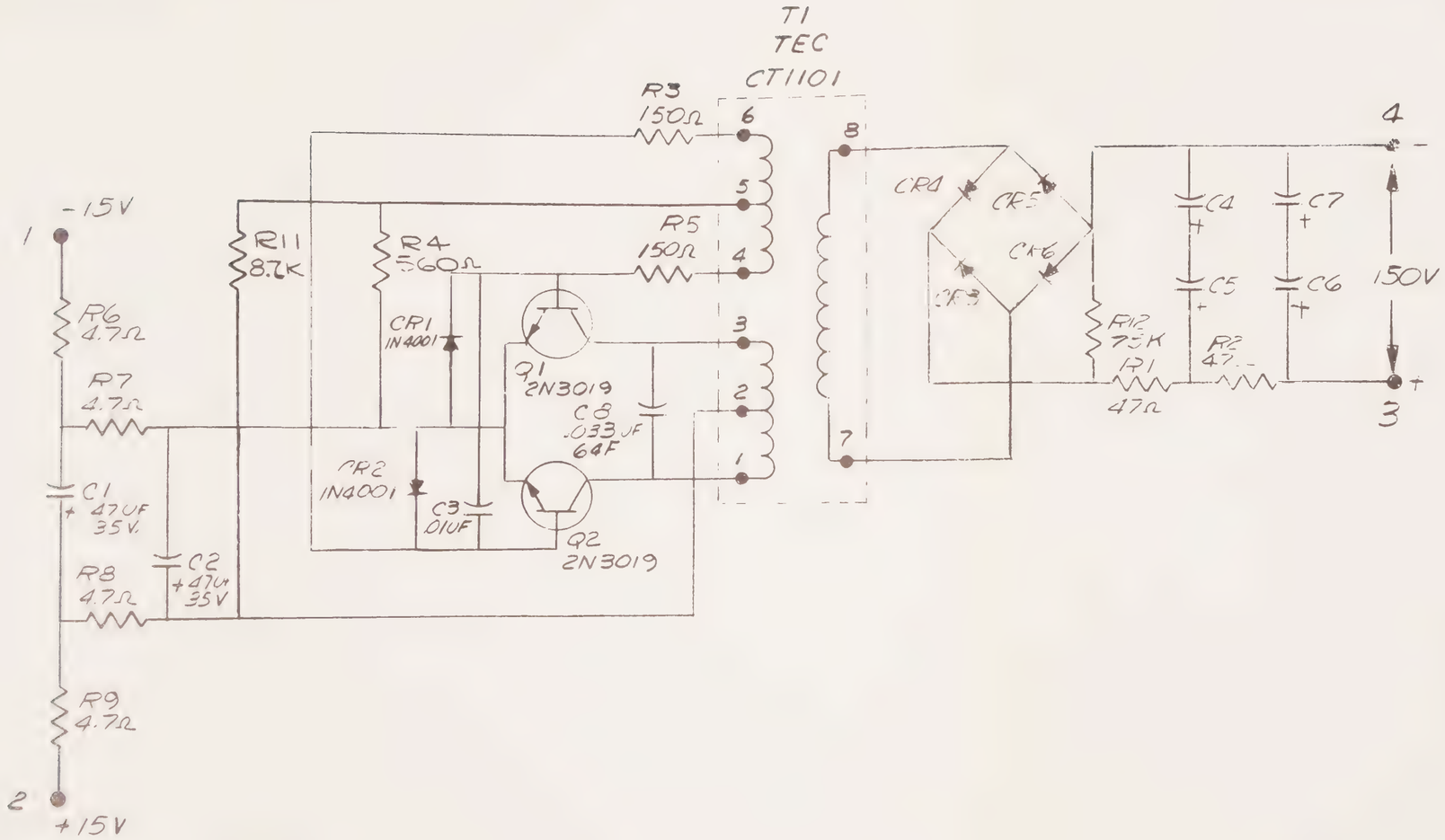


Figure 69. Model 580-26 Silicon Detector Head.

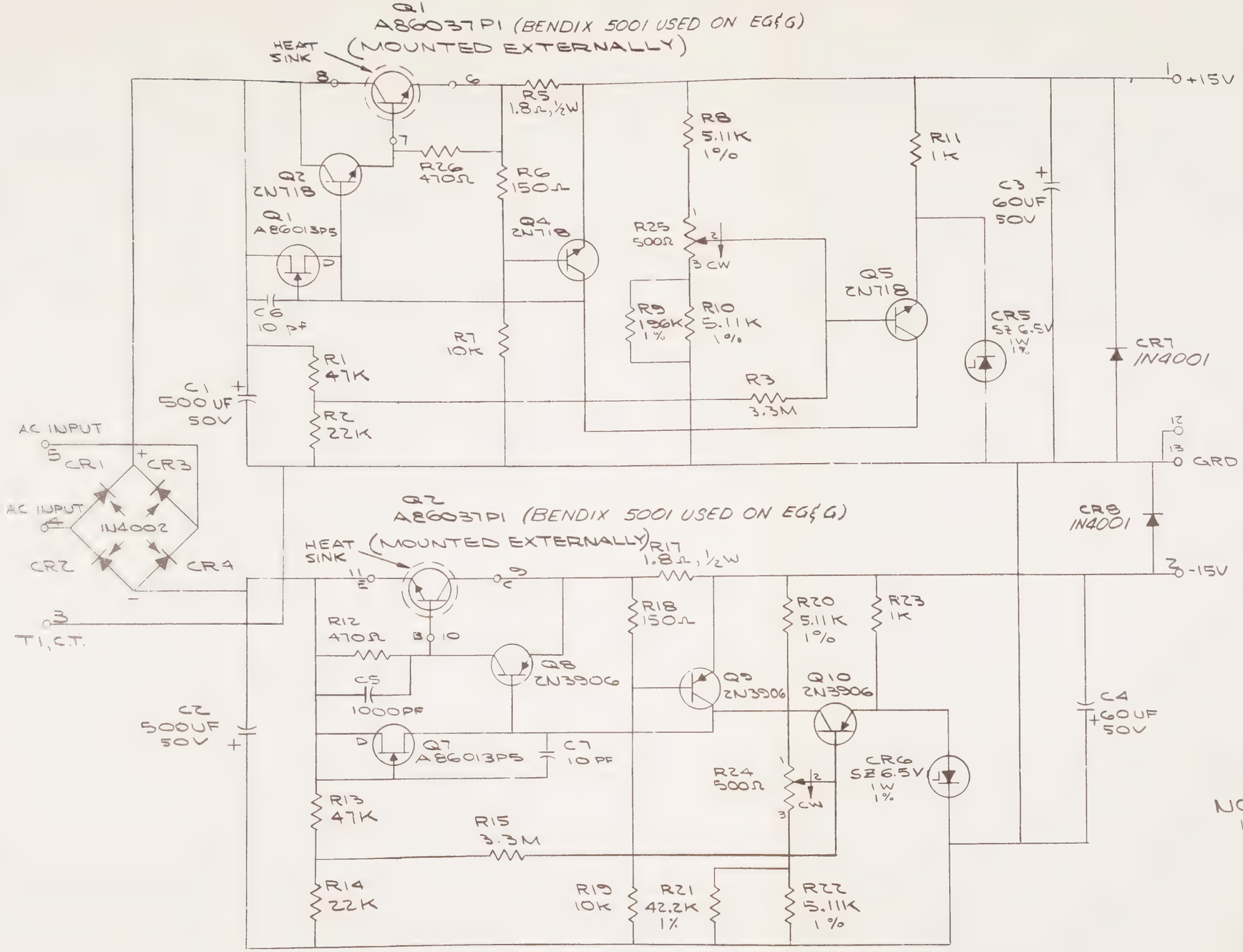


NOTE

1. UNLESS OTHERWISE SPECIFIED
   RESISTORS ARE ¼W, 5%
   CAPACITORS ARE 22UF, 100V, 20%
   SPRAGUE 100D226X0100F2
   DIODES ARE IN4004

Figure 70. Model 580-15 Synchronous Amplifier, 150-Volt Power Supply.

6-15/6-16



NOTES:
1. UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE ¼W, 5%

Figure 71. Model 580-15 Synchronous Amplifier, ±15-Volt Power Supply.

S1 FRONT PANEL SWITCH POSITION	SWITCH POSITION
1	1
10⁻²	2
10⁻³	3
10⁻⁴	4
10⁻⁵	5
10⁻⁶	6
10⁻⁷	7
10⁻⁸	8
10⁻⁹	9
10⁻⁴	10
10⁻³	11

S2	
10	1
3	2
1	3

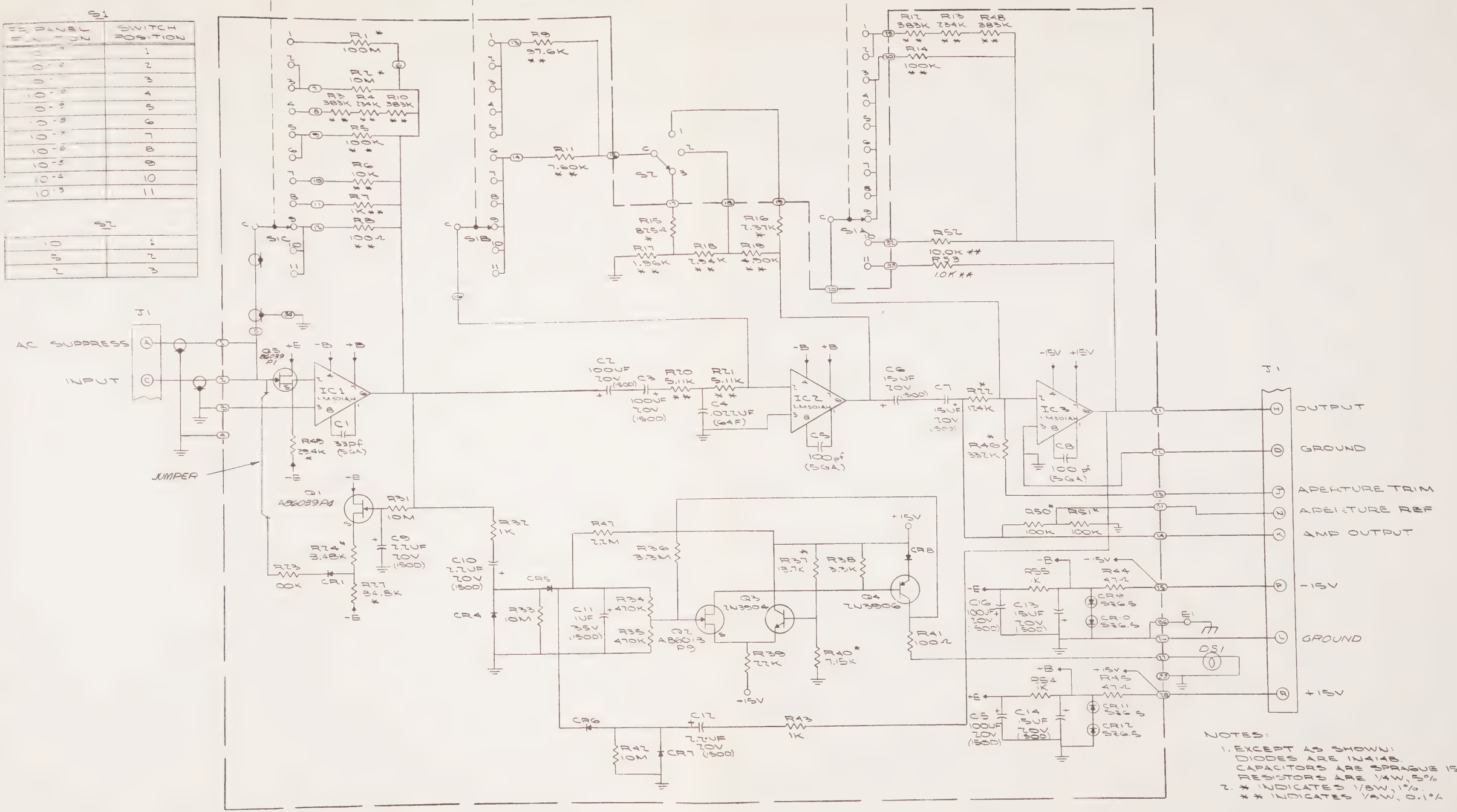


Figure 72. Model 580-15 Synchronous Amplifier, Current Amplifier.

6-19/6-20

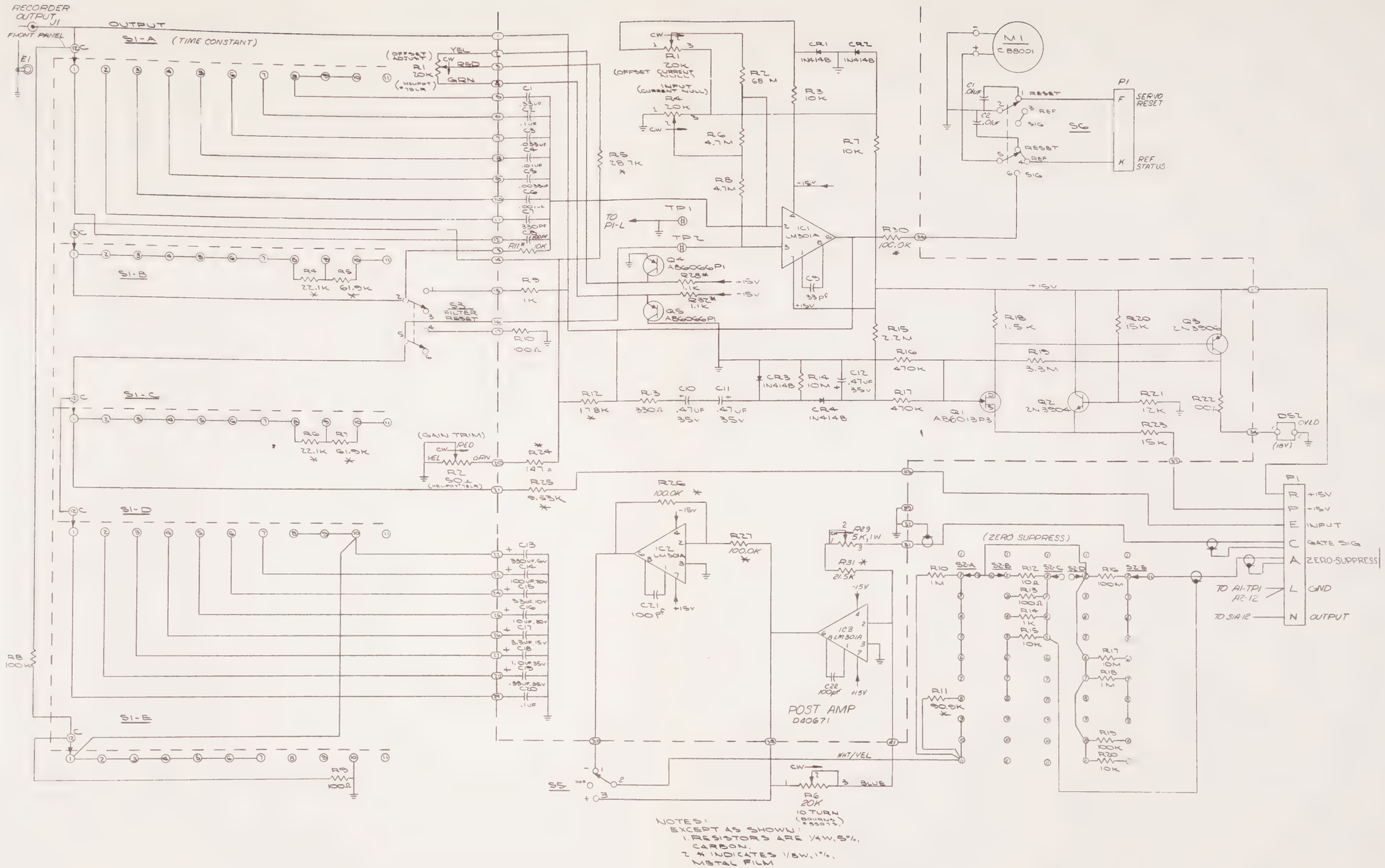
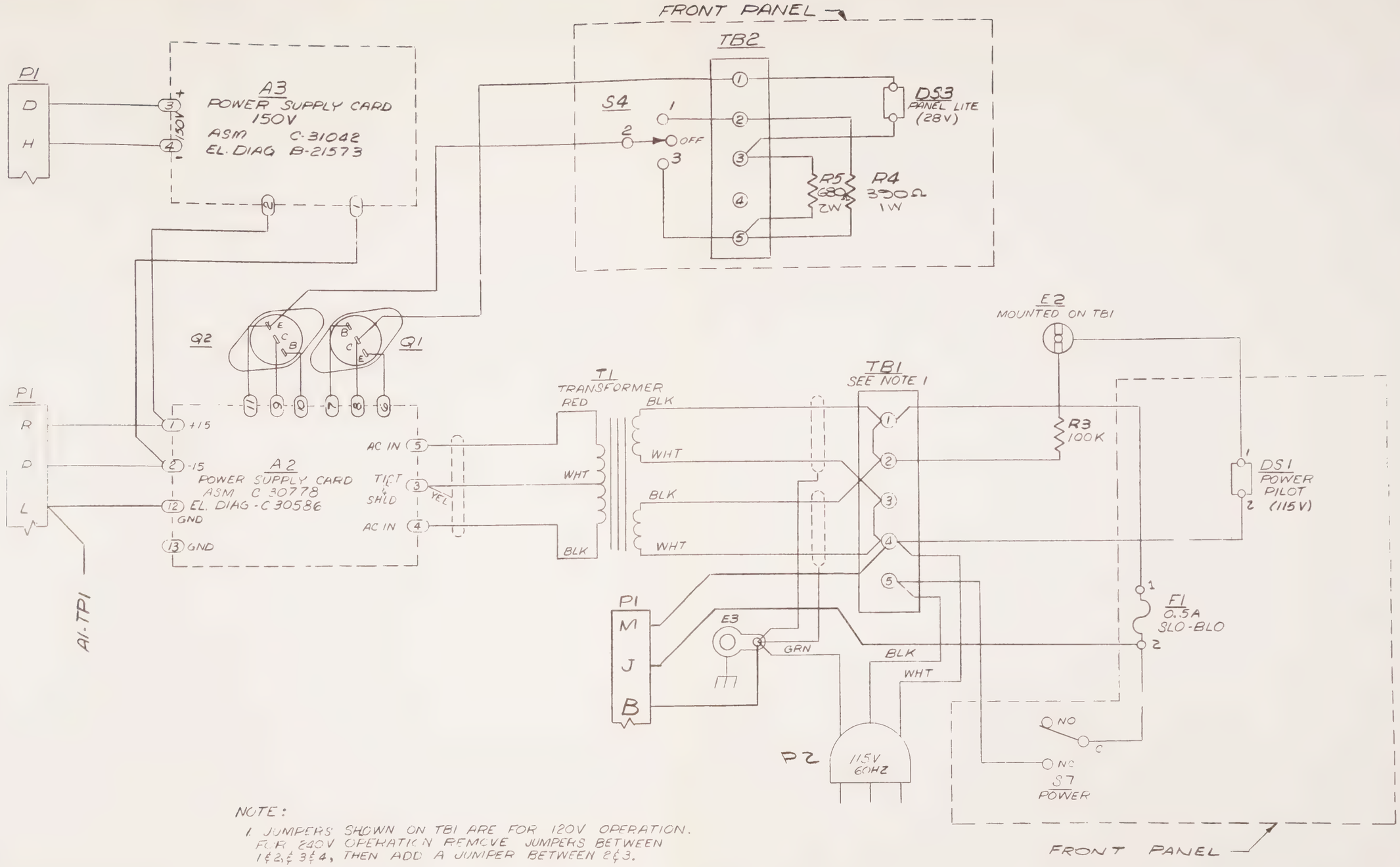


Figure 73. Model 580-15 Synchronous Amplifier, Readout Amplifier.

6-21/6-22



NOTE:

1. JUMPERS SHOWN ON TB1 ARE FOR 120V OPERATION. FOR 240V OPERATION REMOVE JUMPERS BETWEEN 1 & 2, & 3 & 4, THEN ADD A JUMPER BETWEEN 2 & 3.

Figure 74. Model 580-15 Synchronous Amplifier, AC Power Distribution.

6-23/6-24

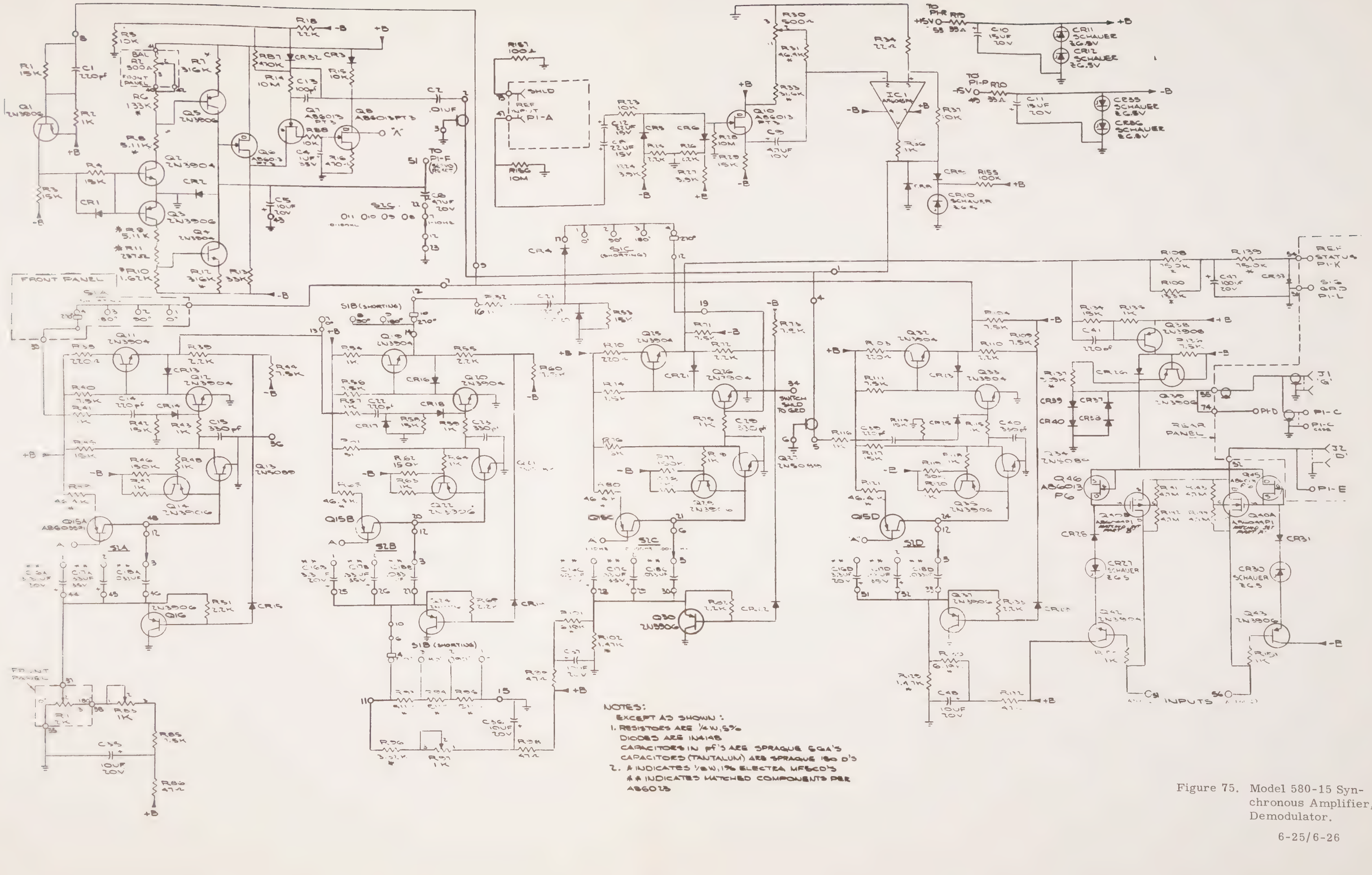
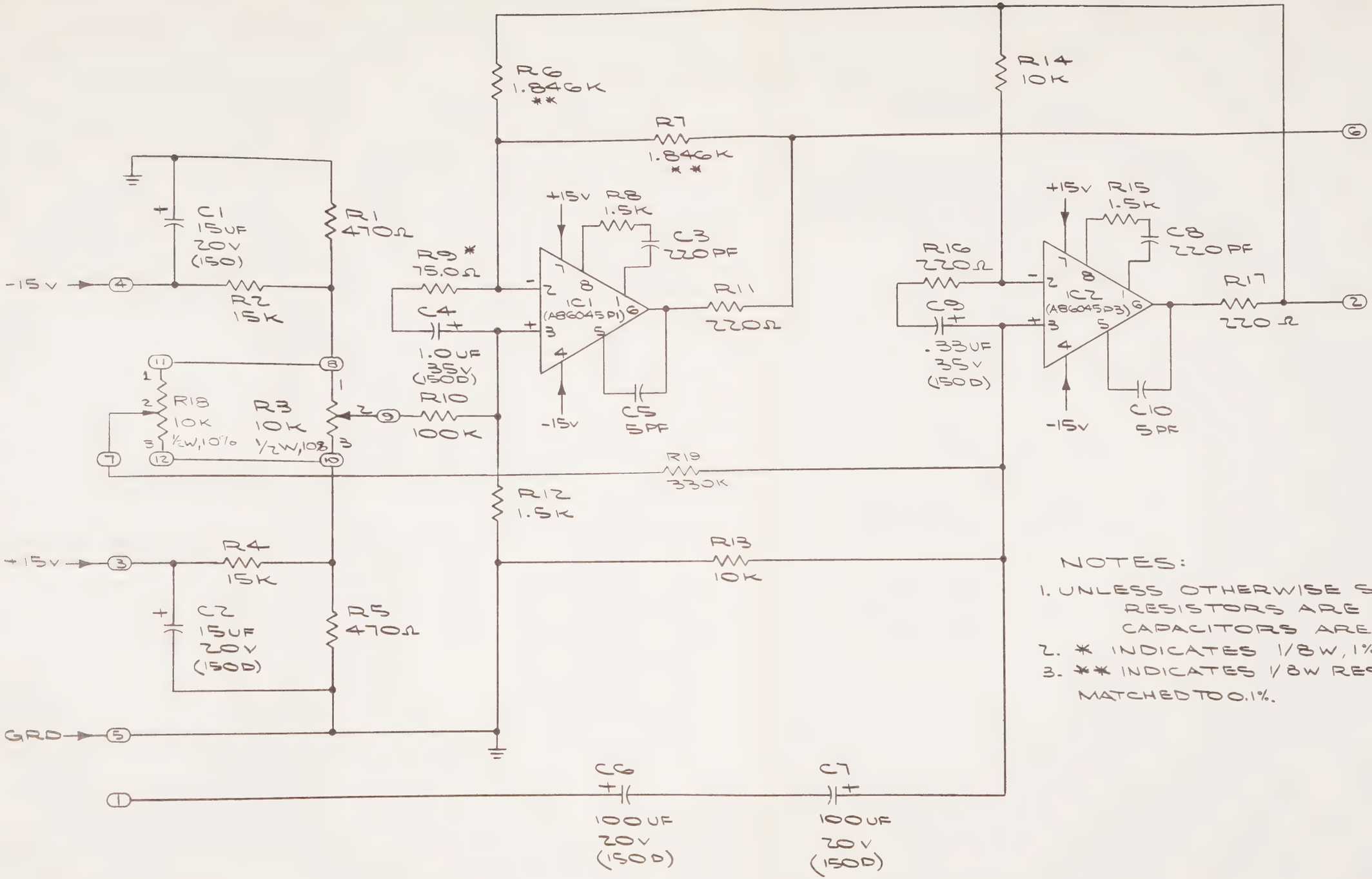


Figure 75. Model 580-15 Synchronous Amplifier, Demodulator.

6-25/6-26



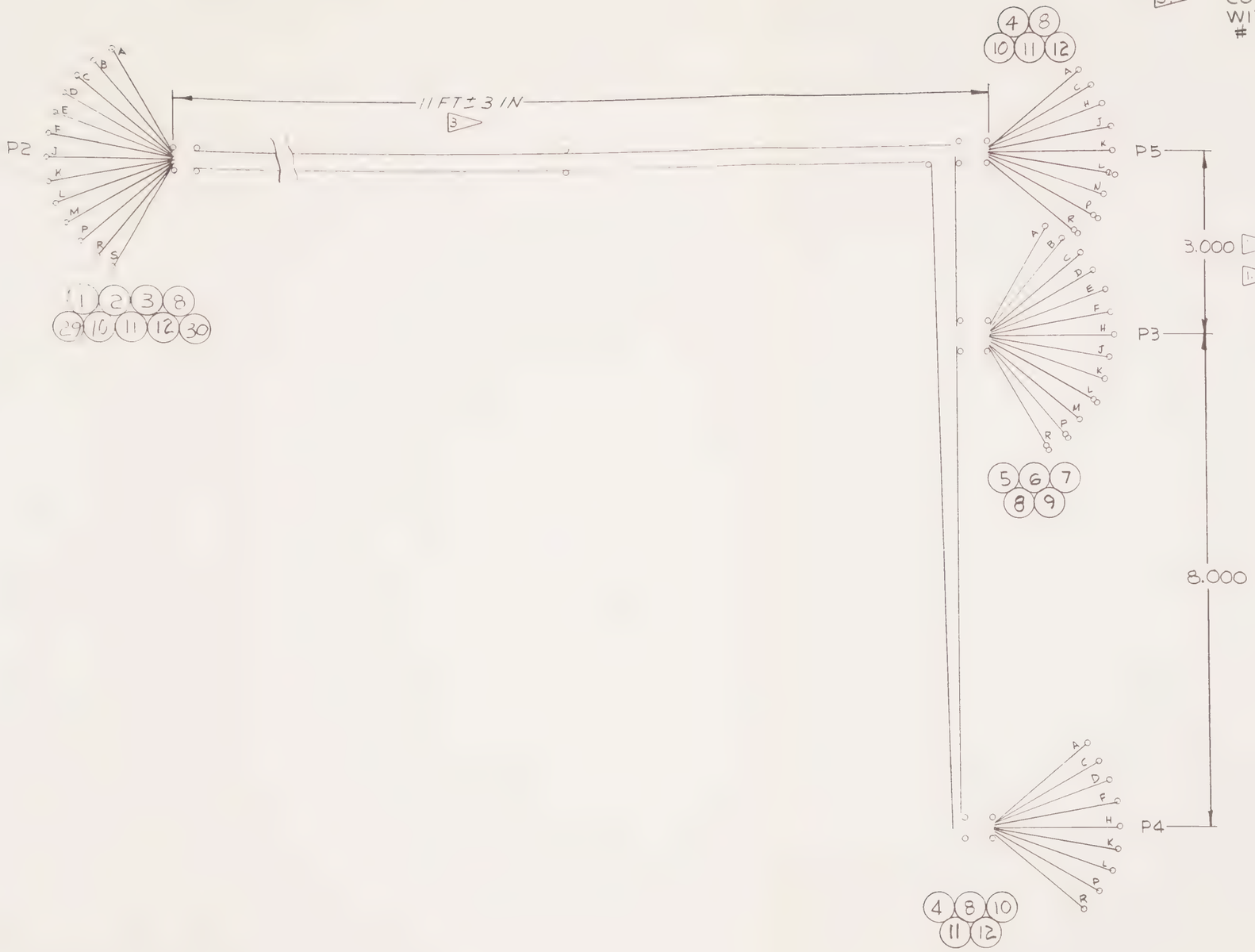
NOTES:

1. UNLESS OTHERWISE SPECIFIED: RESISTORS ARE 1/4W, 5%, CARBON CAPACITORS ARE SPRAGUE 5GA
2. * INDICATES 1/8W, 1% RESISTORS.
3. ** INDICATES 1/8W RESISTORS MATCHED TO 0.1%.

Figure 76. Model 580-15 Synchronous Amplifier, Signal Phase Splitter.

NOTES:

1. THESE WIRES ARE A TWISTED PAIR.
2. NO. 22 AWG WIRE TO BE TEFLON.
3. COVER THIS PORTION OF CABLE WITH SLEEVING, SUFLEX, SIZE 2, # F3B021, ITEM 29.



WIRE LIST

✓	START	FINISH	SIZE	COLOR
	P2-A	P3-J	22 AWG	WHT
	P2-B	P3-H	"	WHT/VIO
	P2-C	P3-M	"	BLK
	P2-D	P5-P	"	VIO
	P2-E	P5-J	"	ORN
	P2-F	P3-D	"	WHT/BLU
	P2-J	P4-A	RG174/U	COAX
	P2-K	P5-L	22 AWG	WHT/BLK
	P2-L	P5-N	"	YEL
	P2-M	P5-K	"	GRN
	P2-P	P3-B	"	BRN
	P2-R	P5-R	"	RED
	P2-S	P5-C	RG174/U	COAX
	P3-A	P5-A	RG174/U	COAX
	P3-C	P4-C	RG174/U	COAX
	P3-E	P4-D	22 AWG	BLU
	P3-F	P4-F	"	GRY
	P3-K	P4-K	"	WHT/GRN
	P3-L	P5-L	"	WHT/BLK
	P3-P	P5-P	"	VIO
	P3-R	P5-R	"	RED
	P4-H	P5-H	"	WHT/YEL
	P4-L	P3-L	"	WHT/BLK
	P4-P	P3-P	"	VIO
	P4-R	P3-R	"	RED

Figure 77. Model 580-15 Synchronous Amplifier, Cable Harness.

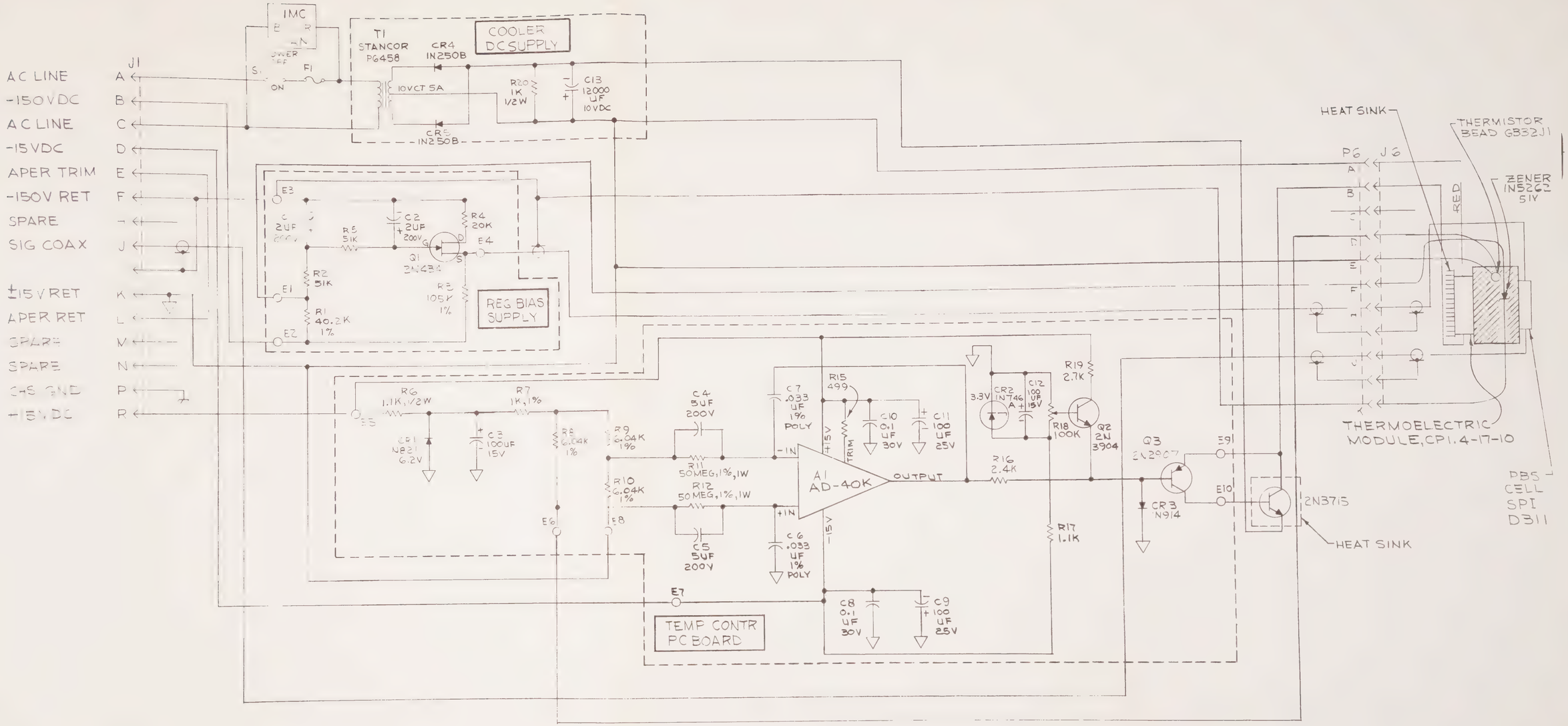


Figure 78. Model 585-55 Lead Sulfide Detector Head.

6-31/6-32

NOTES:
ALL RESISTORS ARE 1%, 1/4W FILM EXCEPT R2 AND R4.

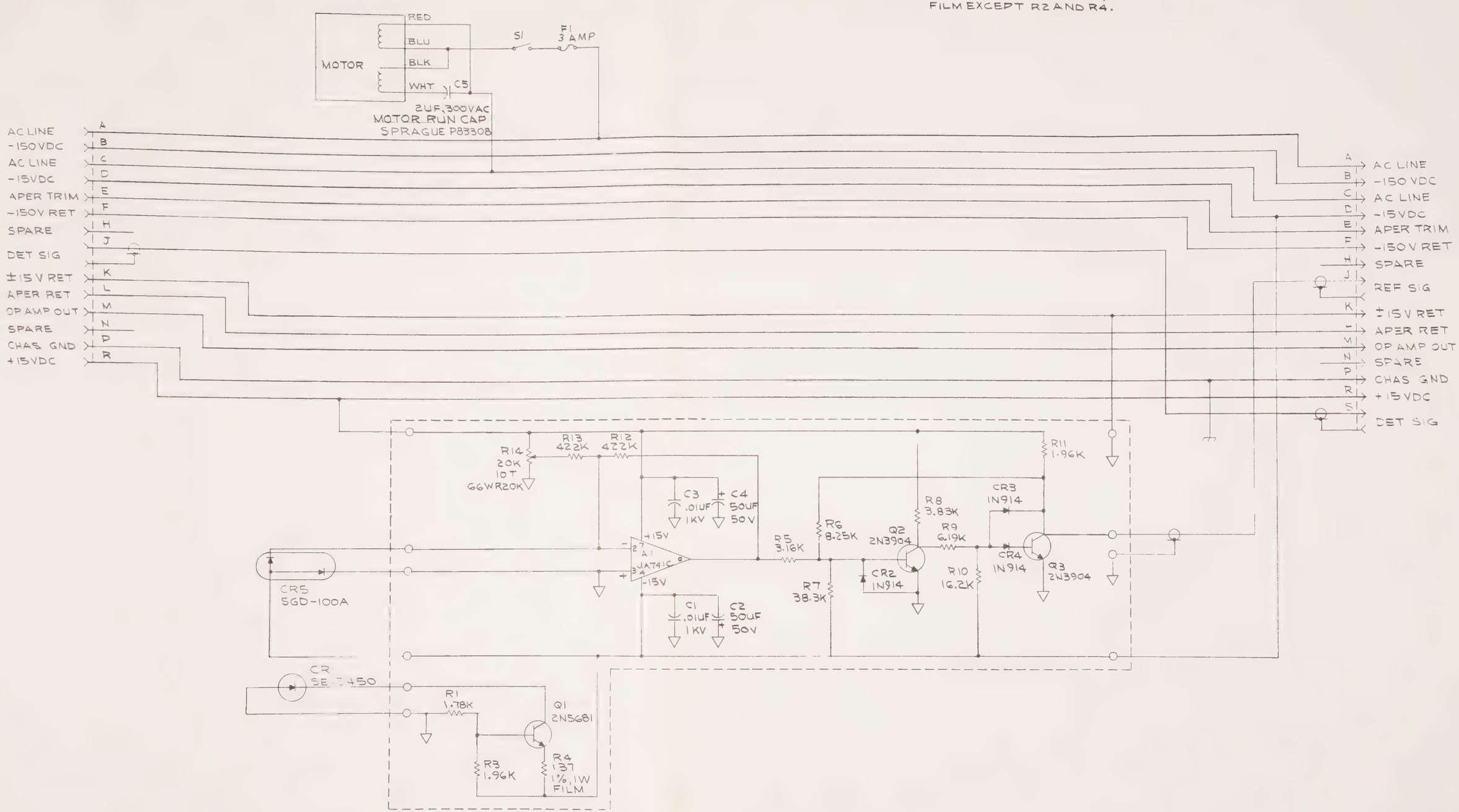


Figure 79. Model 585-42 Chopper.

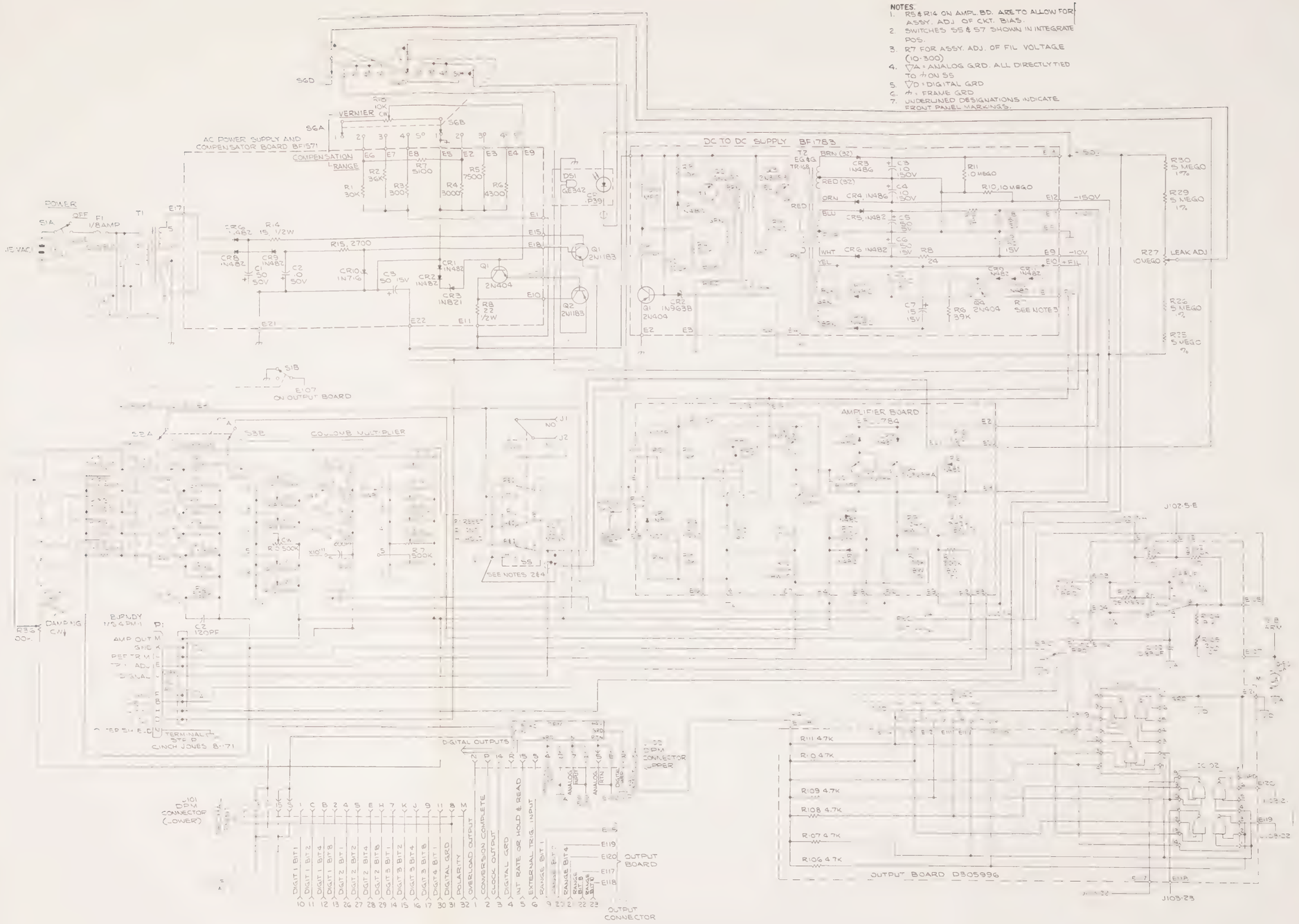

NOTES:
1. R5 & R14 ON AMPL BD. ARE TO ALLOW FOR ASSY. ADJ. OF CKT. BIAS.
2. SWITCHES S5 & S7 SHOWN IN INTEGRATE POS.
3. R7 FOR ASSY. ADJ. OF FIL VOLTAGE (10-300)
4. ▽A = ANALOG GRD. ALL DIRECTLY TIED TO ⏚ ON S5
5. ▽D = DIGITAL GRD
6. ⏚ = FRAME GRD
7. UNDERLINED DESIGNATIONS INDICATE FRONT PANEL MARKINGS.
DC TO DC SUPPLY BF1783
AMPLIFIER BOARD
OUTPUT BOARD D305996
AC POWER SUPPLY AND COMPENSATOR BOARD BF1571
COULOMB MULTIPLIER
DIGITAL OUTPUTS
OUTPUT CONNECTOR
OUTPUT BOARD
POWER
VERNIER ON
COMPENSATION
RANGE
SEE NOTES 2&4
SEE NOTE 3
TERMINAL STRIP
CINCH JONES 8-171

Fig. 80. Model 580-12 Digital Indicator Unit.

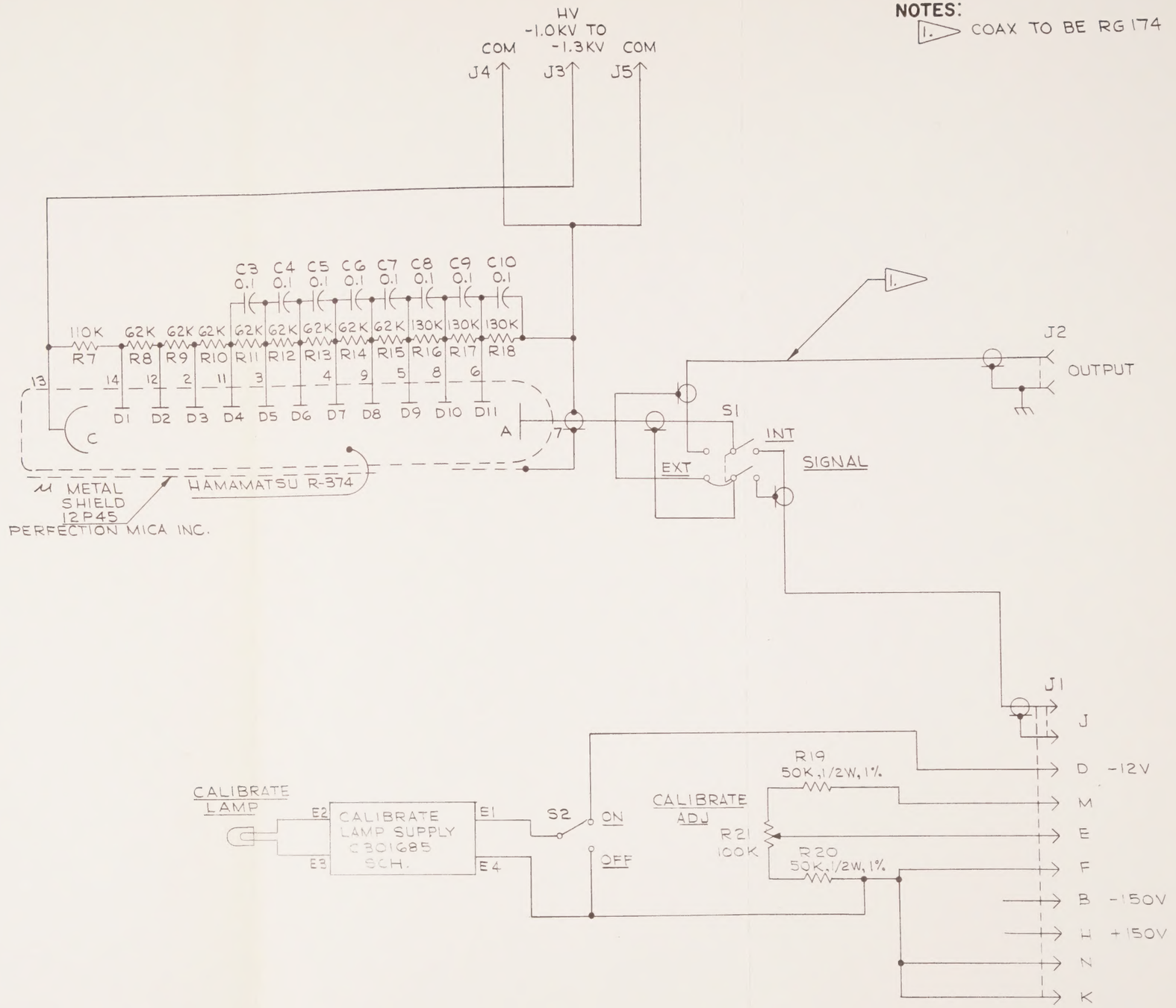


Fig. 81. Model 585-62 High-Sensitivity Detector Head (S-20).

MP MASTER
MA29012